Materials
in Design Engineering

What's New in Materials — Page 5. Self-Filleting Adhesives — Page 12. Water Resistant Coatings — Page 71. Complete Contents — Page 1.

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JANUARY 1961

NEW IDEAS IN COPPER ALLOY ROD AND WIRE

Interesting things happen when you add a spot of zirconium or chromium to copper—four high-conductivity coppers that boost production, cut cost of machining—even plain old free-cutting brass rod is going fancy.

There's a quiet revolution going on in copper metallurgy. Research and development teams are expanding the useful knowledge of copper and copper alloys in an effort to define the properties most suitable for specific engineering applications.

STABILITY at elevated temperature, combined with good electrical conductivity, is probably a combination most sought after by design engineers and by our industry's research teams. Two alloys are now commercially available, and the alloy systems are unique. Chromium copper and zirconium copper are heat-treatable alloys with good stability of mechanical properties up to temperatures in the order of 600 F.

CHROMIUM copper in the fully heat-treated condition following a solution anneal will exhibit properties combining a tensile strength of about 75,000 psi with conductivity of approximately 80% IACS. Zirconium copper has good stability characteristics at elevated temperatures and conductivity of 90 to 95% IACS; the strength properties developed by heat treating are, however, somewhat lower than chromium copper.

SEVERAL other heat-treatable copper alloys with intermediate properties are gaining recognition in the connector and electronics fields. These alloys fall into a conductivity range of 35 to 65% IACS, with tensile strengths 90,000 to 100,000 psi. The most popular alloy systems are the copper-nickel-phosphorus and copper-nickel-silicon series with modifications for free machining or other specific requirements. These alloys have a solution annealing temperature about 100 to 200 C lower than the chromium and zirconium coppers.

THE WIDESPREAD use of panel or harness construction for linking segments of electrical control devices has made the requirement for free-cutting coppers mandatory. Screw machine shops are fabricating these connector components of various designs by the millions. Currently the most popular free-cutting coppers are leaded copper with conductivity of about 98% IACS, and tellurium and sulfur coppers at about 95% IACS. Some of these free-cutting coppers have residual oxygen and can become brittle or gassed under the usual conditions contributing to this phenomenon. All, however, can be obtained with a combination of deoxidizers or oxygen-free copper. In the case of the deoxidized variety, some slight sacrifice in conductivity will be noticed. Ordinary usage very seldom requires conductivity in excess of 90% IACS – and this presents no problem for these coppers.

ALL of these coppers can be cold worked without too much trouble. They can be supplied in a suitable wire temper for cold heading and secondary operations designed around the basic alloy system. Up to now there has not been too much interest in these alloys for wire forming or heading operations. Close dimensional tolerances may be the reason for the reluctance of the heading people to get into the electrical connector business. Alloys are available with the ductility and mechanical properties necessary for this type of forming. It would appear that some of the products could be made more economically by cold-heading or wire-forming operations.

RECENT TRENDS have also affected the old brass and copper reliables. There can't be any product more prosaic than free-cutting brass rod; it is the cheapest of such commodities and at one time was the easiest to process—all one had to do was to extrude, draw to finish dimensions, and ship. In many cases this practice won't work today. Deep drilling, roll threading, knurling, staking, slotting, etc., have complicated the picture, but the latest efforts of the screw machine builders have laid this ghost to rest. We now hear of beta-free rod for close tolerances on deep-drilling applications. Similar grain structures, but not necessarily the same temper, are required for roll threading, knurling and staking or whenever extra ductility is needed. Along with the consideration of grain structure, it has been necessary to take advantage of the broad chemical composition range for free-cutting brass. Most suppliers divide the standard range into two parts, utilizing the lower copper range for the larger sizes that will normally be machined on the heavier, faster screw machines where chip breaking and clearing the tools are the most important considerations. This might be considered the rough, breakdown type of stock.

FOR the smaller diameters, specialization has been the watchword. Depending on specific needs, you can now obtain free-cutting brass rod with all-alpha, fine-grained structure or an alpha-beta fine-grained extruded structure, or possibly a combination of both. For certain applications you might need a coarse-grained, all-alpha structure. Lead dispersion and lead content are other variables that can and will be controlled to meet fabricating or end-use requirements.

IN the cold-heading industry, advantage is being taken of the wider selection of copper and copper alloys that is available today. The nickel silvers, phosphor bronzes, and silicon bronzes combine good ductility and high strength with excellent corrosion resistance. The whole range of common brasses has specific applications and can be tailored to various heading operations.

The research and development hopper is full of interesting new ideas and projects at Anaconda American Brass Co. It could be that we're working on something which would help solve one of your problems. Even though we don't have the complete answer, perhaps we could both reach a solution faster by pooling our efforts. Call your Anaconda representative and talk it over with him or write: Manager, Market Planning, Anaconda American Brass Company, Waterbury 20, Conn.

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JANUARY, 1961 | VOL. 53, NO. 1

Materials in Design Engineering

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What's New in Materials

At a Glance 5

New Urethane Laminates Have Good Flexural Properties 9
More data on a new resin promising for structural uses

Titanium Diboride Now Available in Large, Strong Parts 10
Price is cut . . . refractory slow to oxidize even at 2500 F

Radiographic Standards to be Developed for Thin-Section Castings 11
Reference photos will show defects in walls down to 0.13 in.

New Adhesive Films Give Optimum Glue Line in Honeycomb Structures 12
Self-filleting, unsupported films keep weight to a minimum

New Data on a Polyester Film for Packaging and Electrical Uses 15
Like the Mylar type, it is strong, transparent, stable

Wrought Titanium Alloy Has Better Creep Resistance 17
Graph shows superiority over established 6Al-4V alloy

New Organic Coatings Announced at Paint Industries' Show 17
Include fast-drying urethane, cost-cutting acrylic copolymer

Other Contents 19

Materials Engineering & Design

At a Glance 69

Water Resistant Coatings 71
What types are available and how to select the right one

Where to Use Shell Mold Castings 76
Case histories show how to take advantage of this foundry process

Do You Need Filled TFE? Use Tape to Cut Costs 81
How it is used for lip seals, bearings, sliding surfaces

Heat Treatable Copper Alloys 84
Properties and uses of beryllium coppers, tin-nickel bronzes, etc.

Other Contents 88

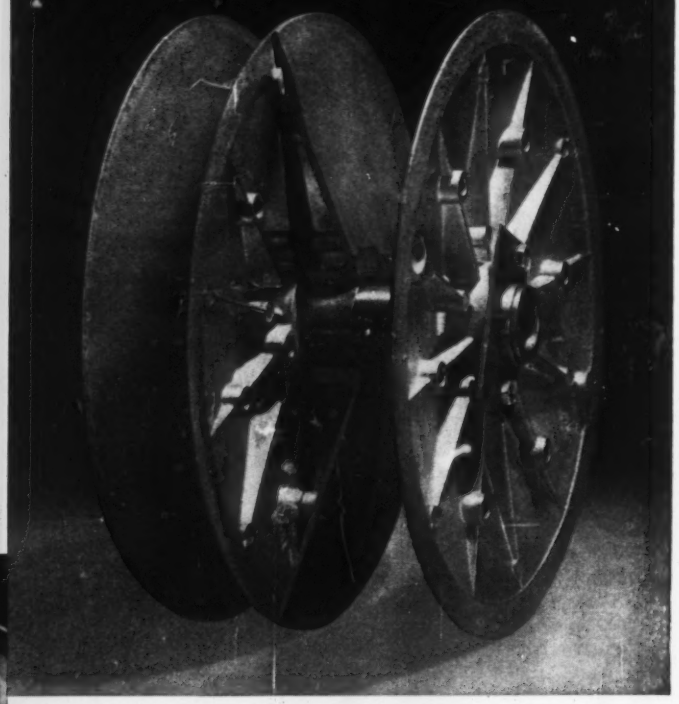
MANUAL NO. 179 **What You Should Know About Creep-Rupture** 89
A look at the variables that affect high temperature strength

CONTINUED ON PAGE 3 →

IT'S LIGHTER THAN YOU THINK!

WITH HIGH STRENGTH THIN-WALL SECTIONS

WHEN DIE CAST WITH ZAMAK



A single zinc die casting—a conical disk 7½" in diameter—used in four different positions, makes up this speed changer mechanism for the General Electric Combination Washer-Dryer.

Cast with hub and radial reinforcing ribs and a projection-recess interlocking system (see view above, with one disk cut away to show cross section) two of these parts are pressed, back to back, on a bronze bearing to form a movable drive ratio adjustment. Two single pieces, locked on the ends of the tube, complete the dual-pulley assembly.

In position 1 (at left), the mechanism provides a regulated low speed for washing, rinsing and drying cycles. Moved upright, as in position 2, the drive is changed from an 8 to 1 ratio for centrifuging speeds during the water-extracting cycle.

Zinc die castings, because of their high strength in thin-wall sections, their dimensional accuracy, smooth surface and low cost, are the logical and obvious answer to the problem of producing these heavy-duty appliance parts.

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CONTINUED FROM PAGE 1

News of Industry

SAMPE Organizes Nationally 21
Is Code for Cryogenic Tanks Too Rigid? 21
ISO Committee Pushes Plastics Standards 23
Metal Powder Parts Competition 23
News of Societies 25
Coming Meetings 27

Reader Service 35

Technical Literature

Suppliers' New Literature 37
Books 43
Reports 44

5th Annual Awards Competition 16
Only a few days left to enter. Deadline: Feb. 1

Prices & Supply

At a Glance 103

The Last Word 166

Needed:
- Wider Dissemination of European Technical Data
- More U. S. Support of International Standards

Other Departments

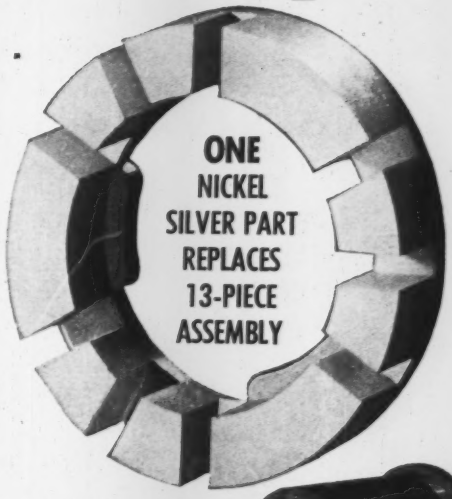
Letters to the Editor 27
Advertising Indexes:
- Products Advertised 163
- Advertisers 164

NEXT MONTH

Chemical Process Equipment: What Materials Are Next?
Ultrasonic Testing of Plastics Moldings
Five Ways to Control High Heat Flux
Zirconium Alloys: Corrosion Resistance and Strength Are Improving
The Newer Insulating Gases
High Strength, Cold Rolled, Austenitic Stainless Sheet
Prize-Winning Zinc Die Castings
Environmental Tests for Elastomers: How Good Are They?
CFE Plastic Used for Blood Filter

This Month's Cover: *A designer's symbolization of the heat envelope surrounding a creep specimen. By Harry & Marion Zelenko.*

METAL POWDERS CUT COSTS $1.97 per piece



INGENIOUS DESIGN SAVES 95% AND CUTS ASSEMBLY TIME FOR STATOR WINDING AT MINNEAPOLIS-HONEYWELL

Formerly, 13 pieces were machined from brass bar stock and fitted by hand to a plastic ring to provide contact points for this assembly.

TOTAL COST WAS $2.07

CONVERTING TO NICKEL SILVER POWDER, ***ONE PIECE,*** DELIVERED BY THE FABRICATOR* READY FOR ASSEMBLY, IS EMBEDDED IN PLASTIC, THEN CUT BACK TO EXPOSE THE ACCURATELY-PLACED TERMINALS — COST 10¢.

*Sintered Metals, Inc., Boston.

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How Electric Home Heat Finally Became a Reality

The extraordinary versatility of Nickel that today brings you electric home heat could tomorrow bring a solution to a metal problem in your own business

Ever have a metal problem you couldn't find the answer to . . . and then discover that the solution was there all the time?

The people in the electric home heating industry needed a resistance wire that had special properties: strength and durability for long-term service – resistance to oxidation and extreme heat – good electrical resistance properties for efficient and economical operation.

They experimented – tested – then found the solution right in their own plants. For years Nickel alloy resistance wire heating elements had made dependable performance a reality in electric ranges, toasters, dishwashers, irons–had in fact introduced a new concept of quality in modern appliances.

This resistance wire – made of a special alloy with a Nickel base – will hold up under years of off-and-on heating and cooling. Will resist heat and corrosion to give the desired long service and trouble-free performance.

Now, Nickel is making electric home heat a practical reality. This winter, for example, nearly one million American homes will be heated electrically. Industry, too, is finding electric heat eminently suitable for plants, stores, office buildings – all types of commercial structures.

Your metal problem. Whether the challenge is one of stress, fatigue, corrosion or temperature extremes, Nickel and its alloys have a durability that's hard to beat. Next time *you* have a metal problem, think first of Nickel. And remember that Inco will be glad to supply any technical data you may need. Just ask us.

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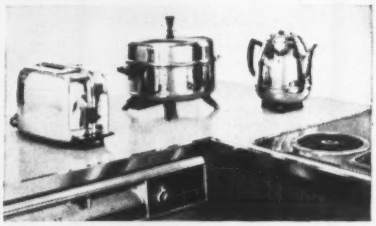

Dependable appliances use Nickel. Electric ranges, dishwashers, toasters, percolators, irons . . . all rely on Nickel alloy resistance wire heating elements for long service life.

This symbol on a new home is your assurance of the ultimate in modern electric living. Look for it when you buy.

FOR MORE INFORMATION ABOUT ELECTRIC HOME HEATING – see your local Electric Power Supplier.

GOLD MEDALLION HOME LIVE BETTER ELECTRICALLY

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

What's new IN MATERIALS

...AT A GLANCE

A modified 'T-1' constructional alloy steel recently introduced is said to cost significantly less than T-1 because of differences in chemical composition. For example, the new steel sells for $47 per ton less than T-1 in open hearth grade extra. The modified steel is available in quenched and tempered plates and bars in thicknesses from 3/16 to 1 in. In this thickness range the new steel has the same 100,000 psi minimum yield strength as T-1 steel. (More details in a forthcoming issue.)

Source: United States Steel Corp., 525 Wm. Penn Pl., Pittsburgh 30.

A new polyurethane sealant is expected to last several times as long as conventional oil-base sealants which have an effective life of one to three years. The new material comes in a single package, requires no field mixing or curing accelerators, and does not shrink on aging. The developer says the material maintains excellent adhesion over the temperature range –165 to 300 F. The polyurethane sealant is presently available in sample lots at $21.50 per gal.

Source: E. I. du Pont de Nemours & Co., Fabrics & Finishes Dept., Wilmington 98, Del.

Better sound absorption and lower cost are the claims made for a new felt covered on one side with a perforated vinyl coating. Tests show the felt absorbs 100% more sound at 600 cps and 300% more sound at 1000 cps than conventional sound absorbing materials. The material, which is flameproof, is recommended for use as a lining material in business machines and similar products.

Source: Western Felt Works, 4021 Ogden Ave., Chicago 23.

Fungus resistant vinyl films can be obtained with a newly developed epoxy-base plasticizing and stabilizing compound. The new plasticizer is expected to broaden the use of vinyl resins for pond liners, floor tile, shower curtains, building covers, and other outdoor and indoor products frequently subjected to fungus attack. The material sells for 40¢ per lb in tank car lots.

Source: Union Carbide Chemicals Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17.

A new zinc die casting alloy with greatly improved castability is now commercially available. Advantages claimed for the alloy are: 1) faster production rates; 2) fewer rejects; 3) larger, more complex castings; 4) better surface finish; 5) lower casting temperatures; 6) thinner wall sections; and 7) less critical die design. The alloy's composition is about the same as that of conventional AG40A (XXIII) and AC41A (XXV) alloys, except that it contains 0.005 to 0.02% nickel and a reduced amount of magnesium (0.005-0.02% vs 0.03-0.08%). Price is comparable to that of other zinc die casting alloys.

Source: New Jersey Zinc Co., 160 Front St., New York 38.

Lower cost ABS plastics, said to provide a combination of impact strength, modulus and hardness similar to that of certain types of previously available ABS plastics,

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Absson T.M.

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have been announced. Priced at 37-49¢ per lb, the materials are said to process easily in conventional injection molding and extrusion equipment. The newly developed materials are reportedly polymerized by techniques differing from those generally used for ABS plastics. (More details next month.)

Source: Monsanto Chemical Co., Plastics Div., Springfield, Mass.

A new leaded manganese bronze is said to have higher tensile strength, less weight and better corrosion resistance than copper-tin and copper-tin-lead alloys. The free-machining material is supplied in extruded solid and hollow bar.

Source: Ampco Metal, Inc., Box 2004, 1745 S. 38th St., Milwaukee 1, Wis.

Two new CFE-type fluorocarbon resins are now available in developmental quantities. One resin, a copolymer, is serviceable up to 350 F, the other, an easier-processing terpolymer, is serviceable up to 390 F. The producer says the resins have good electrical properties, and are virtually unaffected by inorganic acids, alkalis, oxidizing agents, and most inorganic compounds. They can be flexed in thin sections at –320 F. (More details in a forthcoming issue.)

Source: Allied Chemical Corp., Plastics and Coal Chemicals Div., 40 Rector St., New York 6.

A new metal-to-metal surfacing process permits simultaneous spraying and fusing of metal powders on a base metal by means of an oxyacetylene flame. The new method uses a standard oxyacetylene welding outfit with a modified torch tip. It is particularly well suited for hardfacing since alloys of greater hardness can be compounded in powdered form than in standard rod form. (More details in a forthcoming issue.)

Source: Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17.

New organic polymers made of heat stable materials look promising for use in high speed aircraft and missiles. Best polymers found to date are polybenzimidazoles: preliminary tests show that they withstand temperatures up to 1100 F in a nitrogen atmosphere. Other tests show that polybenzimidazoles do not decompose completely at temperatures as high as 1600 F.

Source: Dr. C. S. Marvel, University of Illinois, Urbana, Ill.

Two self-extinguishing epoxy resins now available are expected to find use in laminated aircraft structures, glass and paper-base laminated electrical circuits, filled castings, and aircraft and missile adhesives. Both resins are made self-extinguishing by substituting bromine on the epoxy molecule. One resin is a semisolid containing 49% bromine and can be used in blends with other liquid epoxy resins; the other resin is a solid containing 19% bromine and can be used alone or in blends with other solid epoxy resins.

Source: Dow Chemical Co., Midland, Mich.

RTV silicone rubber applied by aerosol spray is now on the market. According to the producer, the aerosol product is especially useful for applying a thin, uniform encapsulating coating on electronic assemblies and parts.

Source: General Electric Co., Silicone Products Dept., Waterford, N. Y.

Turn to page 9 for more "What's New in Materials"

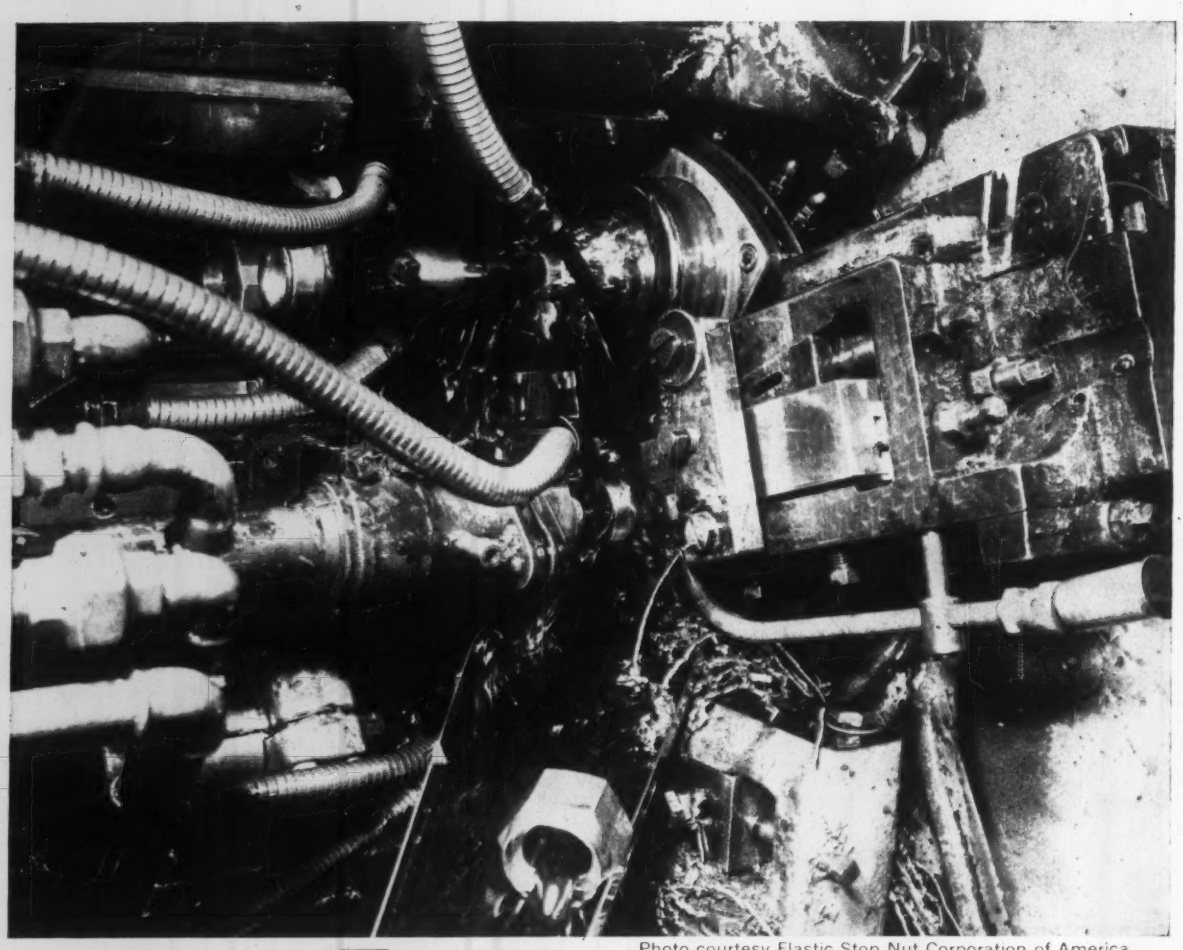

Photo courtesy Elastic Stop Nut Corporation of America

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New Urethane Laminates Have Good Flexural Properties

by A. P. Bonanni,
Aeronautical Materials Laboratory, Naval Air Material Center

■ The data at right show that flexural strength and modulus of a new urethane laminate are superior to those of most conventional reinforced plastics. Such improvements could be useful in a variety of structural applications.

The potential of this new resin, developed at the Aeronautical Materials Laboratory, was indicated by initial evaluation work reported over a year ago (see M/DE, Nov '59, p 182). The data shown here are the result of later evaluations.

The resin system is chemically similar to that used in conventional urethane foam systems. It is made by reacting conventional TDI (2,4-tolylene diisocyanate) with a four-carbon unsaturated glycol. The laminates tested were laid up and press cured under 30-psi pressure for 25 min at 300-350 F.

		FOUR OTHER TYPES[a]			
Laminate →	Urethane[b]	Polyester[c]	Epoxy[d]	Phenolic[e]	Silicone[f]
MECHANICAL PROPERTIES					
Ult Flex Str, 1000 psi					
As Fabricated	90	52-73	53-87	47	35
Wet[g]	79	32-60	48-86	35	35
After 30 Min at 160 F[h]	49	18-35	47-76	32	28
Flex Mod of Elast, 10^6 psi					
As Fabricated	5.0	2.4-4.2	4.1-4.3	3.7	2.1
Wet[g]	5.1	2.8-3.9	4.1-4.4	3.5	2.1
After 30 Min at 160 F[h]	3.2	1.5-2.5	3.1-3.5	2.5	1.7
Ult Ten Str, 1000 psi					
As Fabricated	48	38-53	42-54	45	27
Wet[g]	43	42-45	40-55	36	26
Ult Compr Str, 1000 psi					
As Fabricated	42	22-33	23-49	18	18
Wet[g]	39	13-23	21-42	8	11
Hardness					
Rockwell	M103	M110-117	M72-118	M43	M103
Barcol	69	65-73	56-80	49	60
OTHER PROPERTIES					
Specific Gravity	1.99	1.79-1.99	1.88-2.02	1.75	1.73
Water Abs (24 hr), %	0.31	0.11-0.73	0.05-1.0	7.74	0.19
Flammability, ipm	0.33	0.55 to self-ext	Self-ext	Self-ext	0
Dielectric Constant					
As Fabricated	4.5	4.8	4.3-5.4	4.3	4.1
Wet[i]	5.3	4.8-6.6	5.0-5.8	6.2	4.2
Power Factor					
As Fabricated	0.005	0.005-0.007	0.005-0.010	0.006	0.001
Wet[i]	0.015	0.007-0.070	0.010-0.039	0.064	0.034

[a] Urethane laminates: values are averages for 5 specimens; laminated with 181 style cloth; tested in accordance with Fed Spec L-P-406b.
[b] Average resin content: 28%.
[c] Average resin content: 27-39%.
[d] Average resin content: 21-27%.
[e] Average resin content: 19%.
[f] Fabricated by vendor; resin content not known.
[g] Tested wet after 30-day immersion in water.
[h] Tested at 160 F.
[i] After 24 hr immersion.

Properties

The outstanding charactertistics of urethane laminates are flexural strength and flexural modulus of elasticity. Tensile and compressive strengths are relatively high. Moisture has only a moderate effect on strengths. Temperatures as high as 160 F reduce strengths, but after 30 min at 160 F strength is still superior to that of polyesters, phenolics, silicones, and some epoxies.

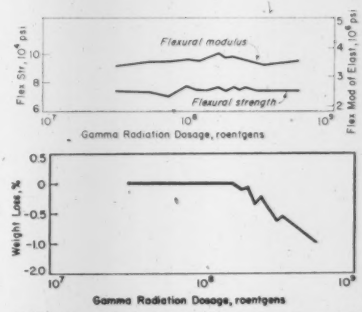
Electrical properties are moderately good but not outstanding.

Effects of radiation on flexural strength and modulus, and the weight loss on irradiation, are shown in the accompanying curves. Gamma irradiation was provided by the cobalt-60 source located at the Laboratory.

Laminates were tested by 24-hr immersion in a variety of fluids, including MIL-0-5606 hydraulic fluid, MIL-E-5559 ethylene glycol, MIL-5-5566 anti-icing fluid, and hydrocarbon fluid. In general, laminates show only a slight increase in weight (on the order of 0.4-0.6%) and excellent retention of flexural strength.

Short pot life

The principal disadvantage of the present resin formulation is the relatively short room temperature pot life, i. e., about 5-6 hr. Although refrigeration extends pot life to about 48 hr, it is not a practical solution.



***Effects of irradiation** on flexural strength and modulus (top), and weight (bottom) of laminates.*

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Bonanni, A. P., "New Polyurethane Laminates," *Space/Aeronautics*, Aug '59, p 87.
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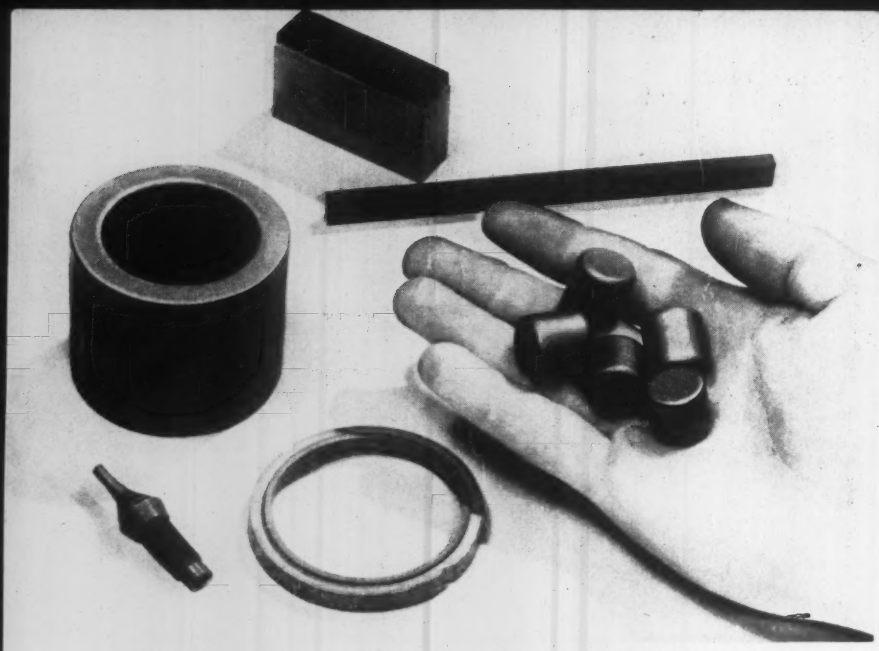
Acknowledgments

The author would like to thank J. H. Bowen, Jr. and C. A. Cassola of the Aeronautical Materials Laboratory for their contributions to this article, and T. Baird for test work in developing the data.



Complex parts—*Parts here are typical of complex shapes in which the material can be produced. Intricate shapes can be easily machined during fabrication.*

Titanium Diboride Now Available as Large, High Strength Parts

This high temperature refractory has been produced developmentally as small parts for several years.

Large parts—*Typical of the large parts in which titanium diboride can now be produced is this 100-lb cylinder, shown with C. A. Odening (left) director of development and C. E. Ford, director of marketing of National Carbon Co.*

■ New processing techniques now permit production of titanium diboride (TiB_2) in parts larger than previously available. Cylinders weighing 260 lb (14 in. dia, 10 in. long) and 100 lb (6 in. dia, 20 in. long) have been produced. Parts made by the new process are also said to have higher strength and greater purity than titanium diboride parts previously produced.

The process was developed by National Carbon Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17. According to C. A. Odening, National Carbon's director of development, production of such sizes and shapes "opens up entirely new markets for this high temperature material." Titanium diboride will be the first of a series of high temperature refractories to be marketed by National Carbon in the future.

Cost figures for custom parts are difficult to estimate. According to the company, the material in "simple shapes" should sell for about $10 to $15 per lb. This represents a drastic reduction from previous costs, which ranged all the way from $50 to $150 per lb.

Properties

National Carbon's new production techniques produce titanium diboride in an extremely fine and uniform particle, and with a purity as high as 99.5%. Shapes have been produced in densities as high as 0.158 lb per cu in., or 99% of theoretical crystal density.

The material maintains a flexural strength of 35,000 psi and an elastic modulus of 60 million psi over a temperature range of 77 to 3600 F, in a protective atmosphere. Oxidation resistance is excellent at temperatures up to 1800 F; even at 2500 F the material oxidizes at a relatively low rate.

Other properties include:

- Hardness of about 3300 Knoop —in the range of boron carbide.
- Coefficient of thermal expansion of 1.4×10^{-6} at 77-400 F; 4.5×10^{-6} at 77-2370 F.
- Thermal conductivity is 14.5 Btu/hr/sq ft/°F/ft at room temperature; 24.2 at 2700 F.
- Electrical resistivity is 20-30

microhm-cm at 68 F; 80-100 microhm-cm at 1800 F.

▶ Inertness to molten aluminum, zinc and slags, but not to molten ferrous metals.

Although its hardness makes fabricated titanium diboride virtually unmachinable except with diamond tools, intricate shapes can be machined with conventional tools during processing.

Applications

The material's high temperature strength coupled with its light weight (about half the weight of steel and only 12% heavier than alumina) make it promising for lightweight ball and roller bearings for high temperature equipment such as jet and rocket engines.

High hardness would make it suitable for milling media, such as balls and cylinders; granular abrasives for finishing hard metals; cutting tools for hard metals; and abrasion resistant surfaces such as wear plates, knife edges and sandblasting nozzles.

The low electrical resistivity of National Carbon's grade of titanium diboride is expected to result in one of the first major uses for the material: lead-in connections to cells used in producing aluminum. The material is attacked neither by the molten aluminum nor by the corrosive salts used in aluminum production. Use of titanium diboride leads may permit radically new designs in aluminum cells.

The material's inertness to molten zinc and slags may result in its use for crucibles, pumps, tapping spouts, funnel linings, valves and gates used in processing nonferrous metals. KEY NO. 600

Radiographic Standards to be Developed for Thin-Section Castings

■ American Brake Shoe Co., was recently awarded a contract by the Naval Ordnance Laboratory to produce reference radiographs that will illustrate defects which commonly occur in relatively thin steel castings used in airframes.

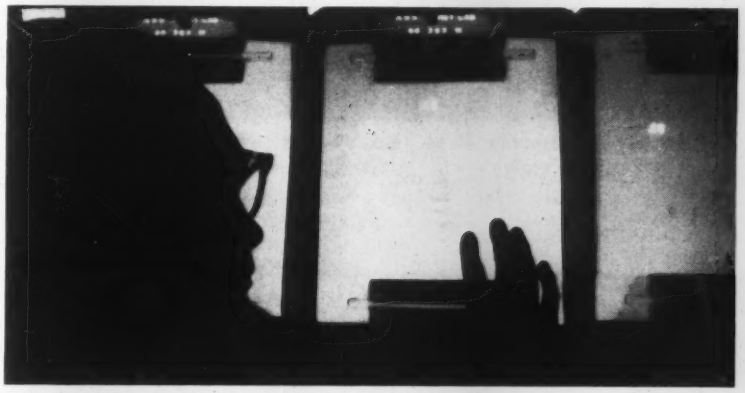
Present standards apply only above ¾ in.

Although radiographic standards have been available to the steel castings producer and consumer for many years, they could be applied only when the thickness of the casting exceeded 0.75 in. But recent developments in the foundry industry have made thin steel castings available and their application in the aerospace industries has increased considerably.

Since the performance demands on these castings are severe, it is vital that the castings be dependably sound. NOL recognized the need for radiographic standards for thin-section castings and laid the groundwork for preparation of a standard radiographic reference manual for the castings industry.

Specifications spell out materials, sizes, defects

The contract awarded to American Brake Shoe requires that defective castings be produced with wall thicknesses ranging from 0.13 to 0.75 in. Test castings are 8 in. long and 6 in. wide.



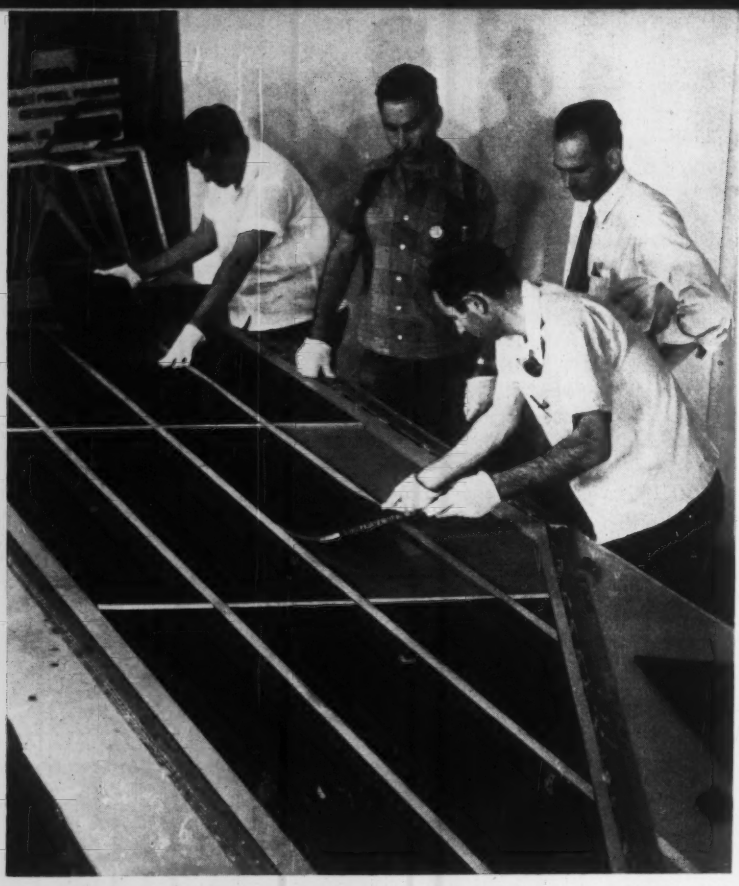
Shrinkage *patterns for a thin-section casting are examined on a radiograph. (Flaw has been "retouched" in order to reproduce it clearly here.)*

Using alloy steels, AISI 4130, 4140, 4330, and 4340, and stainless steels 3471, 410, 430 and 17-4PH, castings will be produced with the following defects: inclusions, cold shuts, shrinkage, cracks, porosity, hot tears and misruns. Individual castings must contain only a single type of defect and each radiograph must identify the size and shape of the flaw. In most cases, radiographs will display a given defect in several degrees of progressively increasing severity.

How castings are produced

Casting procedure parallels that used to produce aircraft and missile castings. Metal is poured into ceramic molds to minimize surface defects. Mold design, rate of pouring and metal temperature are varied according to the type of flaw desired.

Plates are cast with and without taper to produce varying degrees of soundness. Risers vary in size and are, at times, eliminated. Chills are used in some molds, and in others local appendages are attached to produce hot spots in order to vary shrinkage.



Aircraft panel assembly *shows how simple it is to use new adhesive. Adhesive film can be seen directly underneath honeycomb sheets.*

New Adhesive Films Give Optimum Glue Line in Honeycomb Structures

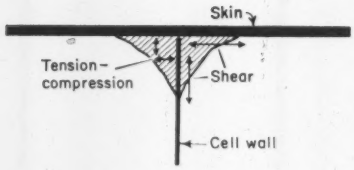
because they are unsupported, self-filleting

by Dr. F. J. Riel, *Narmco Laboratories, Div. of Telecomputing Corp.*

■ Newly developed adhesive systems now make it possible to achieve maximum efficiency in designing the glue-line in honeycomb sandwich constructions. By so designing, sandwich materials can be made to provide maximum strength-weight ratio, reliability and economy.

The new adhesives are self-filleting, unsupported films. They are 100% solids, elastomer-modified epoxy formulations. Shear and tensile strengths are higher than those of elastomer-modified phenolic adhesives. Because the films are unsupported all the adhesive weight is used to form the structural fillets.

Table 1 compares typical properties of one of these adhesives (Metlbond 408) with specification requirements. The adhesive shown is intended for a service temperature range of −300 to 200 F. Other formulations under development should extend the upper limits of this range.



1 *—How stresses are distributed in a honeycomb fillet.*

Why self-filleting?

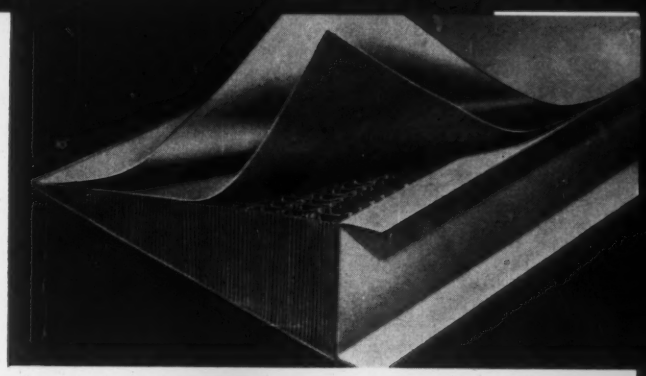
These adhesives have been developed to meet the structural needs of honeycomb structures.

In a honeycomb sandwich the adhesive not only bonds the skins to the core, but serves a structural function of its own. The cumulative cross-sectional area formed by the foil-thin edges of the honeycomb cell walls adds up to less than 15% of the area of the facing surfaces. This provides an insufficient mating surface. Also, the chances of obtaining a perfect match between all the edges of the cell walls and the skin are very slight, even in flat panels. To effectively increase the mating surfaces enough to obtain optimum structural strength, the core-to-skin adhesive must form structural fillets between the skin surface and the inside cell walls of the honeycomb core.

Fillet stress analysis — The structural theory of honeycomb sandwiches is now well established (see Mar '60, p 117).

The stresses imposed on the core-to-skin adhesive fillet are diagrammed in a simplified fashion in Fig 1. When the sandwich is stressed, shear stresses are imposed parallel to the skin surface. When the skin is in compression and starts to buckle away from the core, the adhesive-skin interface is loaded in tension. At the same time the adhesive-core interface is loaded in shear. Between the core cell wall and the skin is the bulk adhesive itself, which

Unsupported film adhesive *has no carrier to decrease efficiency of sandwich.*



Adhesive film *is shown here between honeycomb core and facing.*

must have the cohesive strength to withstand the tensile and shear forces acting at right angles on it.

A honeycomb cell structure when overloaded tends to collapse in an accordion-like manner. Crumpling, or pleating, starts at the extreme edges of the individual cell walls. Extensions of fillets along the cell walls from the skin strengthen the cell wall, increasing the panel's resistance to failure by compressive buckling.

Consequently, strength requirements of a good adhesive include high tensile and shear strengths, both cohesive and adhesive. Also, ideally the adhesive should be applied as a smooth fillet which extends equally along the skin surface and up the cell wall.

TABLE 1—ADHESIVE PROPERTIES VS SPECIFICATIONS

Property[a] ↓	MIL-A-25463A Requirement	Typical Properties (Metlbond 408)
SANDWICH CONSTRUCTIONS		
Peel Str, lb/in. width		
Room Temp	8.5	50
At 180 F	5	30
At −67 F	2	15
Flatwise Ten Str, psi		
Room Temp	540	1000
At 180 F	270	400
At −67 F	350	1200
Flex Str, psi		
Room Temp	1750	2200
At 180 F	1200	1400
After 192 Hr at 180 F	1000	1800
Creep Defl, in.[b]	0.050	0.035
METAL-TO-METAL BOND		
Ten Shear Str, psi		
Room Temp	2500	6000
At 180 F	1200	3000
At −67 F	2500	5000
Creep Rupture (max defl at 180 F), in.	0.015	0.005
Bend Test, psi	150	300
Fluid Immersion Test (MIL-A-5090B)	—	Passes all tests

[a]Test methods as designated in specification. [b]Max deflection for 800-lb load after 192 hr at 180 F.

Older methods lack efficiency

Since one of the principal purposes of honeycomb sandwich structures is to attain high strength-to-weight ratios, the adhesive should meet structural requirements with maximum efficiency. As much of the weight of adhesive as possible should contribute directly to strength.

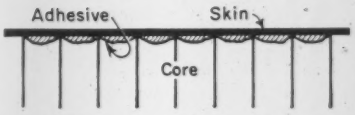
Also, the adhesive must permit economical assembly and cure, and since no practical method exists for inspecting the inside of a sandwich structure once it has been assembled, the core-to-skin adhesive system must be essentially foolproof.

Two commonly used methods of bonding have been: 1) rubber-modified phenolic adhesives, and 2) supported adhesive films.

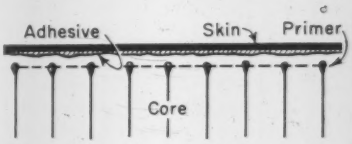
Rubber-modified phenolic adhesives provide excellent adhesion to the skin surface. But they do not satisfactorily wet the core surfaces. As shown in Fig 2a, when applied without primer the adhesive film depresses at the junctions of the skin and cell walls.

The problem has been solved in the past by priming the cell wall edges (see Fig 2b) prior to assembly, usually with a similar type of adhesive. When skin and core are joined, the adhesive layer and primer merge to form satisfactory fillets in the final structure, as shown in Fig 2c. The resulting structure has satisfactory strength and serviceability, but the production process is long, tedious and costly. Also, excess adhesive remaining on the surface of the skin opposite the cell cores adds weight without contributing to strength.

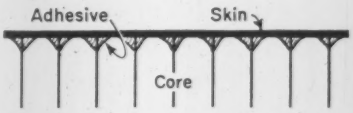
Rubber-phenolic adhesives for sandwiches



2a—*Without primer, adhesive does not fillet but rather depresses when core is pressed into applied film.*



2b—*Here primer has been applied to ends of core cells.*



2c—*Cross section of assembled honeycomb sandwich shows satisfactory fillets built up by priming.*

A more recent method is the use of "asymmetric" adhesive films consisting of glass or synthetic fiber cloth or scrim impregnated with the rubber-phenolic and coated on one side with an epoxy adhesive which has good wetting characteristics. During cure, the epoxy resin flows up the cell walls,

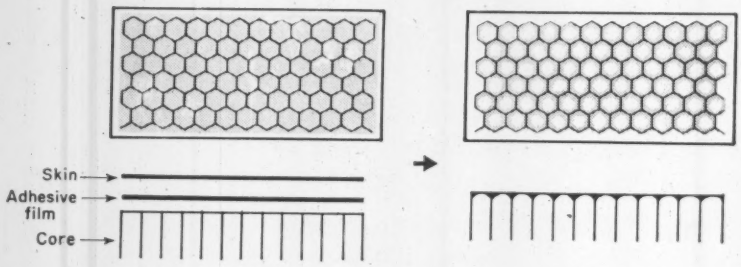
forming the fillets, while the rubber-phenolic forms a strong resilient bond with the skin surface.

However, the cloth carrier covers the entire skin surface, resulting in wasteful excess weight in the centers of the core cells. The carrier cloths require careful tailoring and fitting in order to prevent lapping of layers of cloth. Also, the epoxy adhesive tends to fail in a brittle fashion when used to bond large areas of metal to metal. Consequently, in sandwich structures involving bonding of both core to skins and metal to metal, two adhesive systems have had to be used, each with its own processing methods and cure cycles.

An additional disadvantage in using any phenolic-type adhesive has been the volatiles generated by the curing reaction. Sandwich constructions have to be perforated to allow these volatiles to escape. Such perforations later allow moisture to collect within the core structure. Moreover, phenolic-bonded panels have generally required pressure cures to force the volatiles out of the glueline itself.

How the new adhesives work

The new adhesives are supplied as dry unsupported films. In applying the film, a film weight is used that will provide fillets of just the thickness required for the necessary cohesive and adhesive strengths, and no more. The exact amount depends on cell size, since the size affects the total linear dimension of the fillets. The smaller the cells, the shorter the fillet "legs" required for structures of equal strength.



3—*How the new adhesive works.* ***Left****—assembly components with unsupported adhesive film in place.* ***Right****—assembled sandwich showing how adhesive gathers at core-skin interfaces forming efficient fillets.*

Fig 3 shows schematically the assembly before joining, and the filleted assembly after joining and cure. The filleting action of the adhesive starts in the early stages of cure. At 150-250 F the adhesive loses most of its film strength, becoming soft and crumbly. The low stresses in the film cause the adhesive to shrink and gather at the points where it is held in place by contact between core and skin. The film is still relatively tack-free, so that all the adhesive tends to "ball up" in these fillet areas, leaving the skin surface in the center of each cell completely free of adhesive. When the temperature approaches 350 F the adhesive melts and forms a solid fillet of almost perfect dimensions with equal "legs" on core surface and skin surface.

TABLE 2—A COMPARISON—ADHESIVE WEIGHT VS STRENGTH

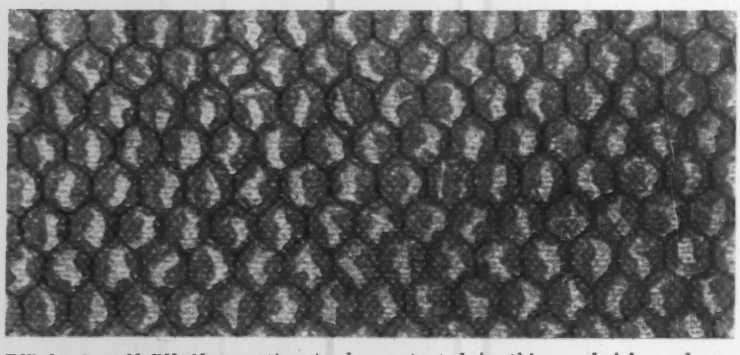
Adhesive Type	Adhesive Wt, lb/ft	Peel Str, lb/3-in. width[a]
Primed Core	0.075-0.09	35
Asymetric (supported) Film	0.08-0.10	70
Fillet-Forming (unsupported) Film[b]		
Light Duty	0.045-0.055	150
Heavy Duty	0.08-0.10	300

[a]Climbing drum method.
[b]Two weights and strengths show variability in strengths obtainable by altering amount of adhesive.

Since no adhesive is wasted at the cell centers, total adhesive weight in a given sandwich is sharply reduced. Typical panels have been built with only 0.05 lb of adhesive per sq ft, as compared with 0.09 to 0.10 lb per sq ft for both the modified phenolic adhesives (including primer) and the asymmetric tape films. Table 2 compares weights of various types of panels with resulting peel strengths.

The fact that no carrier is used also permits films to be overlapped at will. Strength data indicate that the adhesive can be used for both core-to-skin bonding as well as metal-to-metal bonding. The adhesive flows easily to fill any voids in mating surfaces.

The effect of surface tension and wetting action is so strong that we have found no detectable difference between fillets formed on the top of the core and those on the bottom.



Efficient self-filleting *action is demonstrated in this sandwich made up with a clear glass skin on one side. Note how adhesive gathers at interface of cell wall and skin, leaving center of cells clear. Adhesive weight is concentrated in fillets.*

TABLE 1—TYPICAL PROPERTIES OF TERAFILM POLYESTER FILM[a]

PHYSICAL PROPERTIES	
Color	Water white
Specific Gravity	1.228
Area Fact., 1000 sq in./lb/mil	22.6
Ten Yld Str, 1000 psi	11
Ult Ten Str, 1000 psi	19.3
Ult Elong, %	70
Ten Mod of Elast, 10^5 psi	4.6
Ten Impact Str, ft-lb/in.	580
Tear Str (Elmendorf), gm/mil	7
Burst Str (Mullen), psi	56
Fold Endurance (MIT), cycles	>10,000
Water Vapor Transmission, gm/100 sq in./24 hr	1.8
Water Absorption, %	0.25
Gas Transm, cu cm/sq m/24 hr[b]	
O_2	230
N_2	80
CO_2	880
SO_2	None
Heat Dist Temp (2%; 50 psi), F	340
ELECTRICAL PROPERTIES	
Dielectric Constant (1 kc)	
At 77 F	3.15
At 170 F	3.11
At 212 F	3.12
At 255 F	3.19
Dissipation Factor (1 kc)	
As Supplied	
At 77 F	0.0043
At 170 F	0.0022
At 212 F	0.002
At 255 F	0.0072
After 8 Days at 230 F and 100% RH (0.1 kc):	
At 77 F	0.004
At 122 F	0.002
At 170 F	0.003
At 212 F	0.004
Dielec Str vs Thk (500 v/sec, 60 cps, 77 F), v/mil	
0.0005 In.	8700
0.0010 In.	5900
0.0020 In.	4200
0.0050 In.	2700
0.0100 In.	2100

[a]Values for 1-mil film except where noted.
[b]0.8-mil film.

TABLE 2—YIELD AND COST[a]

Gage ↓	Approx Yield, 1000 sq in./lb	Approx Cost, ¢/1000 sq in.[b]
50	45.2	5.5
100	22.6	8.0
200	11.3	15.9
300	7.5	23.9
500	4.5	39.8

[a]Figures are intended to be only indicative.
[b]Costs in widths of 1½ in. or over, on rolls 9½ in. o.d., 3 in. i.d. Specially produced film in gages down to 25 is available for use in critical electrical applications; cost is slightly higher.

***Clear film** compares favorably with Mylar types.*

Here are the latest property data on a . . .

New Polyester Film for Packaging and Electrical Uses

■ Recently revealed property data indicate that the new polyester film, Terefilm (see M/DE, Nov '60, p 112), compares favorably in many respects with polyethylene terephthalate type polyester films.

A strong, durable, highly transparent film, Terefilm has excellent electrical properties. It is particularly stable under conditions of high temperature and humidity. Table 1 lists typical physical and electrical properties of the film. Table 2 gives yield and cost information.

Applications

Primary uses of the film are expected in:

1. Electrical applications, where it could be used for insulating cable and wire, capacitors and coils, and for slot liners, or tapes.

2. Packaging applications, where it might be used as laminating bases, printed webs, shrink wrapping, and as substrates for extrusion.

Other anticipated uses include magnetic tape and metallic yarns.

The film is produced by Terefilm Corp., an affiliate of Acme Backing Corp., Canal and Ludlow Sts., Stamford, Conn., from a polyester produced by Eastman Chemical Co. Chemically, the polyester is a poly-(1,4-cyclohexylenedimethylene terephthalate).

Limited quantities of the film are now available from pilot plant production. Acme expects commercial production by about midyear.

KEY NO. 602

It's not too late to win $500

in the 5th Annual Awards Competition for Best Use of Engineering Materials

16 CASH AWARDS	FIRST AWARD $500 and plaque	FIVE AWARDS OF MERIT $100 each and certificate	TEN CITATIONS $50 each and certificate

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

Rules of the Competition: A Brief Summary *(For complete details, see the December issue, pp 113-116.)*

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1960.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 1, 1961.*

For description of last year's award winners see May '60 issue, pp 139-162.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

Name _____ Title _____

Name(s) of person(s), group or organization who would receive award _____

_____

Company _____

Street address _____ City _____ State _____

Name or brief description of product being entered _____

_____

Was design (or redesign) of entry either completed or placed in production during 1960? _____

Does your employer consent to entry under terms of this competition? _____

Wrought Titanium Alloy Has Better Creep Resistance

Temperature ceiling for titanium alloys is raised by new bar and forging stock

■ A new titanium alloy, Ti-8Al-1Mo-IV, has better creep resistance than the established Ti-6Al-4V. The difference between the two is shown in the accompanying Larson-Miller plot. The new alloy's room temperature mechanical properties are slightly lower than those of 6Al-4V.

The 8Al-1Mo-IV alloy is available as rolled bar and forging billets from Titanium Metals Corp. of America, 233 Broadway, New York 7, N.Y. Sheet products are available only on an experimental basis.

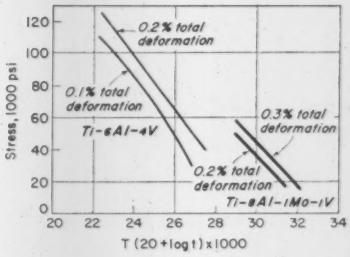
Forgeability

Forging characteristics of the new alloy are similar to those of other alpha-rich, lean beta titanium alloys. Disks and blades have been produced with dies and forging practices similar to those used with 6Al-4V. The basic difference is that while 6Al-4V cannot be forged at temperatures exceeding 1750 F, the new alloy can be forged up to 1950 F. The higher temperature is needed to increase the certainty of filling the die. Lowest forging temperature is 1800 F because of cold cracking and die filling problems.

Heat treatment, properties

For the best combination of properties—including creep resistance and rupture life—duplex annealing is suggested. The duplex cycle involves an initial solution anneal at 1650 to 1850 F for 1 hr, followed by air cooling. This is followed by a stabilizing anneal for 8 to 24 hr at 1000 to 1100 F.

Highest creep resistance is obtained after an initial solution anneal at 1950 F on metal that has been alpha-beta processed.



***Larson-Miller** plot of elevated temperature properties of Ti-8-Al-1Mo-1V compared to Ti-6Al-4V.*

Guaranteed minimum tensile properties of 8Al-1Mo-1V bar are: 120,000 psi yield strength (0.2% offset); 130,000 psi ultimate strength; 10% elongation (in 4×dia); and 20% reduction in area. These properties are similar to those guaranteed for 6Al-4V. KEY NO. 603

New Organic Coatings Announced at Paint Industries' Show

They include a fast-drying urethane, a cost-cutting acrylic copolymer, and new linear polyesters

■ As in the past, the annual meeting of the Societies for Paint Technology and the associated Paint Industries' Show (Chicago, Nov '60) provided a good opportunity for end users to catch up on new developments in organic coatings. Although the yearly technical meeting and show places much attention on coating formulations, the end user is not overlooked; if alert he can pick up some valuable information on new coatings that can lead to improved product life and appearance.

Here is a summary of new developments announced at this year's Show.

Fast drying urethane vehicle

Recent shows have been noteworthy for announcements of new developments in polyurethane coatings. The latest of these is a new fast-drying polyurethane vehicle, Spenkel F-78, announced by Spencer Kellog and Sons, Inc., Buffalo 5, N. Y.

The new stable vehicle is available in one-can systems which are capable of drying tack-free in as little as 10 min and which can be recoated in from 3 to 4 hr. The vehicle provides a tough finish which, despite its high hardness, is claimed to have excellent flexibility. Finishes based on the new vehicle also have high resistance to wear, marring and abrasion, are not affected by water, and are easily cleaned. In addition, they have excellent solvent compatibility and, if required, can be readily pigmented.

Coatings based on the polyurethane vehicle can be applied easily by spraying, brushing or dipping. Typical recommended applications include: industrial equipment, maintenance coatings, floors, furniture, panels, marine applications and traffic paint. KEY NO. 604

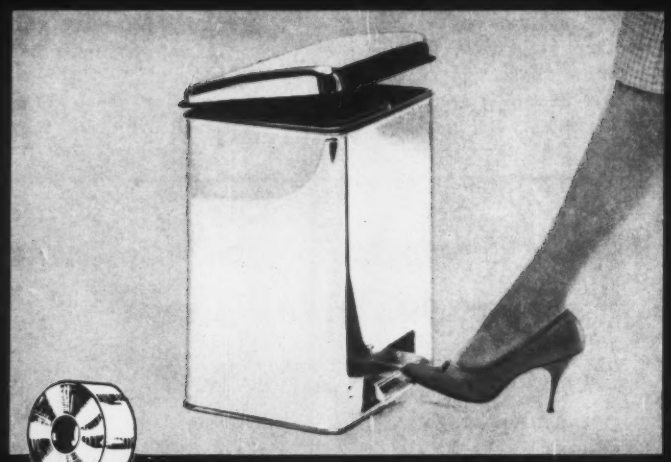
Properties of new two-part coating can be easily adjusted

Researchers at Archer-Daniels-

NICKELOID IS EVERYWHERE

IN THE GAME ROOM

IN MOST ANY ROOM



IN THE KITCHEN

These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).

Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

These handsome articles of daily use are striking indeed! Not a little of this is achieved by the functional use of bright plated Nickeloid Metals in Chrome, Brass or Copper finishes. But look again! These pictures carry a deeper, even more dramatic story . . . the story of a *new concept* of manufacture. Not always do artisans work with raw steel sheet. Not always is the final finish applied by the extra step of painting or plating. With Nickeloid Metals this finish is built-in, and it's done by a company which has dedicated itself to electroplating of sheets and coils for industry for over 60 years! The use of Nickeloid Metals as a pre-finished raw material proves the theorem that a straight line is the shortest distance between two points. Write for free Introductory Kit that unfolds the entire story and provides you with metal samples. Or, phone a Nickeloid sales office in one of the principal cities.

AMERICAN NICKELOID COMPANY • PERU 6, ILLINOIS

America's Pioneer Manufacturer of Pre-Finished Metals — Since 1898

Midland Co., Minneapolis 2, have developed a two-component coating, Aroflint 505, whose performance characteristics are said to equal those of competitive epoxy, urethane and polyester coatings. For proprietary reasons, A-D-M would not disclose the basic resin system used. But they said that the new coating is potentially useful because of its:

1. Color retention, which is outstanding compared to epoxy and urethane coatings and only slightly inferior compared to high grade coconut alkyd - melamine baked coatings.
2. Excellent adhesion to most surfaces.
3. Excellent flow that develops high gloss.
4. Easy adjustment to produce hard and tough, or very flexible, slick-surfaced coatings.
5. Easy pigmentation.
6. High solids content obtainable at application viscosities.
7. Pot life of 16 to 48 hr.
8. Ability to be air dried, force dried or baked.

Of special interest is the fact that the ratio of the two components can be varied to obtain different degrees of hardness, flexibility and other properties. The optimum ratio for hardness and chemical resistance is a 50:50 blend (by weight on a solids basis) of the two components. Suggested uses are marine finishes, primers, floor finishes, and finishes for construction and industrial equipment requiring a durable, high gloss surface with good color retention, mar resistance and toughness. KEY NO. 605

New styrene-acrylate copolymer soluble in low cost solvents

The Chemical Div. of Goodyear Tire & Rubber Co., Akron 16, has developed a styrene-acrylate copolymer (Pliolite AC) which is readily soluble in low cost solvents —a feature which offers distinct economic advantages over straight acrylics. Solutions of the copolymers are said to dry rapidly to form tough, hard films with outstanding resistance to chemicals, water and ultraviolet light.

The copolymer can be dissolved in many commercial solvents (notably aromatic hydrocarbons) with a wide range of drying characteristics. It has almost no solubility in aliphatic solvents; however, the aliphatics can be used to dilute the aromatics for economical formulation. With few exceptions, finishes based on the copolymer dry by solvent evaporation; they are not subject to chemical reaction, nor do they require catalysts to form protective films.

The copolymer has excellent pigment binding properties and for this reason is recommended for applications where a good, long-lasting color is needed. Typical recommended applications are masonry paints, industrial maintenance finishes, concrete enamels, swimming pool paints, traffic marking paints and multicolor finishes. KEY NO. 606

New group of polyester solution resins

In addition to the new copolymer described above, Goodyear's Chemical Div. is also now producing a new group of high molecular weight, linear polyester solution resins known as Vitel. Coatings based on the new materials combine outstanding resistance to abrasion and ultraviolet light with excellent adhesion, clarity, hardness and electrical properties.

Solutions of the polyesters produce continuous, glossy and non-tacky films. Application may be accomplished by any of the conventional methods popular today—brushing, dipping, spraying, or knife and roller coating. Suggested uses include coatings for metal, wood, plastics, paper, leather and textiles. The resins also have potential usefulness in adhesives and printing inks, and as binders for masonry finishes, concrete floor enamels and traffic paints. KEY NO. 607

Magnet Wire Withstands 500 F

■ A magnet wire covered with a new type of insulation is said to have excellent abrasion resistance and good heat resistance.

The developer, Hitemp Wires Co., Div. of Simplex Wire & Cable Co., Westbury, N. Y., says the wire can be used continuously at temperatures above 500 F.

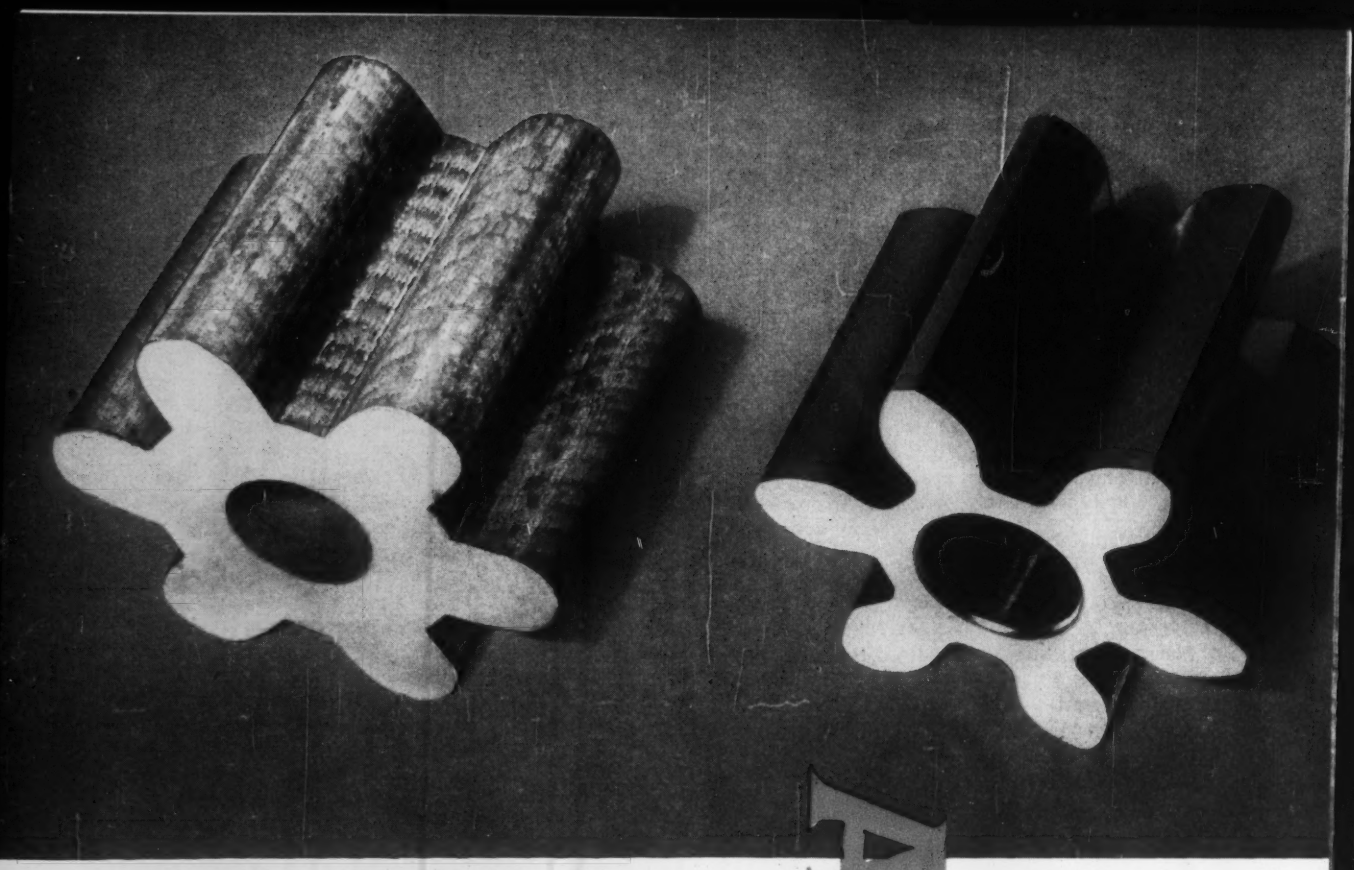
The insulation, described as a crosslinked polymer (composition not disclosed), is said to overcome the problems of cold flow and poor resistance to impregnating and potting compounds which are often encountered in other high temperature insulations.

KEY NO. 608

MORE WHAT'S NEW IN MATERIALS

Adhesives for wood, plastics 121
Alloy steel for anti-smog devices..... 122
Decorative asbestos sheets 124
Improved epoxy paint 126
Intermetallic can be magnetic, nonmagnetic . 126
Crack resistant polyethylene 128
Clad metal tube sheets.... 128
High strength alumina for metallizing 130
Air hardening steel 130
Thin ceramic coating protects airframes 132
Tungsten formed by high energy process 134
Polystyrene sheet for lighting applications ... 136
Solder-clad metals 136
Permanent magnet 138
Bondable FEP film 140
High nickel alloy 142
Flexible magnetic tape ... 142
Vulcanized fibre is flame resistant 144
Bonded graphite 144
Corrugated vinyl sheet ... 146
Photoemissive coating ... 148
Gas chromatography tubing 148
Metal-filled silicone 150
Urethane insulation 150
Coatings made of low cost resins 152
Rubber-to-metal seals ... 156
Air curing silicone waterproofs leather 156
Glass-bonded mica 158
Other news 158

For more information, circle No. 321



Note minimum clean-up necessary between casting of this 6-tooth pump impeller and finished part. (Illustrated parts are 4" in diameter.)

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For more information, turn to Reader Service card, circle No. 332

SAMPE Organizes Nationally

■ The Society of Aerospace Materials and Process Engineers has become a national organization, with eight autonomous local chapters becoming charter members.

Increased communication is national SAMPE goal

The local chapters filled the important need of bringing together technical people concerned with the evaluation and selection of engineering materials in the aircraft and missiles field. Merger into a national organization is expected to foster a greater interchange of information. (For background information see M/DE, July '59, p 212; Oct '59, p 250; Feb '60, p 142.)

The eight charter chapters are: 1) Baltimore-Washington, 2) Delaware Valley, 3) Los Angeles, 4) Midwest, 5) San Fernando Valley, 6) San Gabriel Valley, 7) Seattle, and 8) St. Louis. The Massachusetts and Dallas-Ft. Worth chapters are expected to join early in 1961. It is anticipated that the new chapters starting in Wichita, Orlando, San Diego and San Francisco will affiliate within the year.

New officers elected

The officers elected at the business meeting held in Dallas in October were: president—Bernard Silverman, Lockheed Aircraft Corp., vice president—G. F. Holback, Martin Co., secretary—Frank E. Robinson, General Electric Co., treasurer—H. V. Newman, Beckman Instruments Inc.

In the immediate future the national organization will issue a bimonthly newsletter. Headquarters will be near Los Angeles.

Is Code for Cryogenic Tanks Too Rigid?

■ The safety codes requiring steel storage vessels for liquefied gasses to be stress relieved after fabrication were recently shown to be unnecessarily restrictive.

In a demonstration called "Operations Cryogenics," sponsored by International Nickel Co., Inc., Chicago Bridge & Iron Co. and United States Steel Corp., two types of tanks made of 9% nickel alloy steel in the quenched and tempered condition were filled with liquid nitrogen at −320 F and stressed to failure. Neither tank had been stressed relieved.

***Nickel steel tank is ripped open** but does not shatter at −320 F from overloading with liquid nitrogen. The flying fragments are part of the insulation.*

One vessel, simulating a type that might be used for shipboard transportation of liquid methane, was filled and tested by repeatedly striking it with a 4340-lb wrecking ball. The kinetic energy of the heaviest impact was about 82,500 ft-lb, far beyond that of any blows a tank would likely receive in service.

In the other test, a tank representative of land-based storage tanks was continuously pumped full of liquid nitrogen until it burst (see photo). It withstood pressure at least six times greater than that now permitted in low temperature vessels made from this steel and stress relieved.

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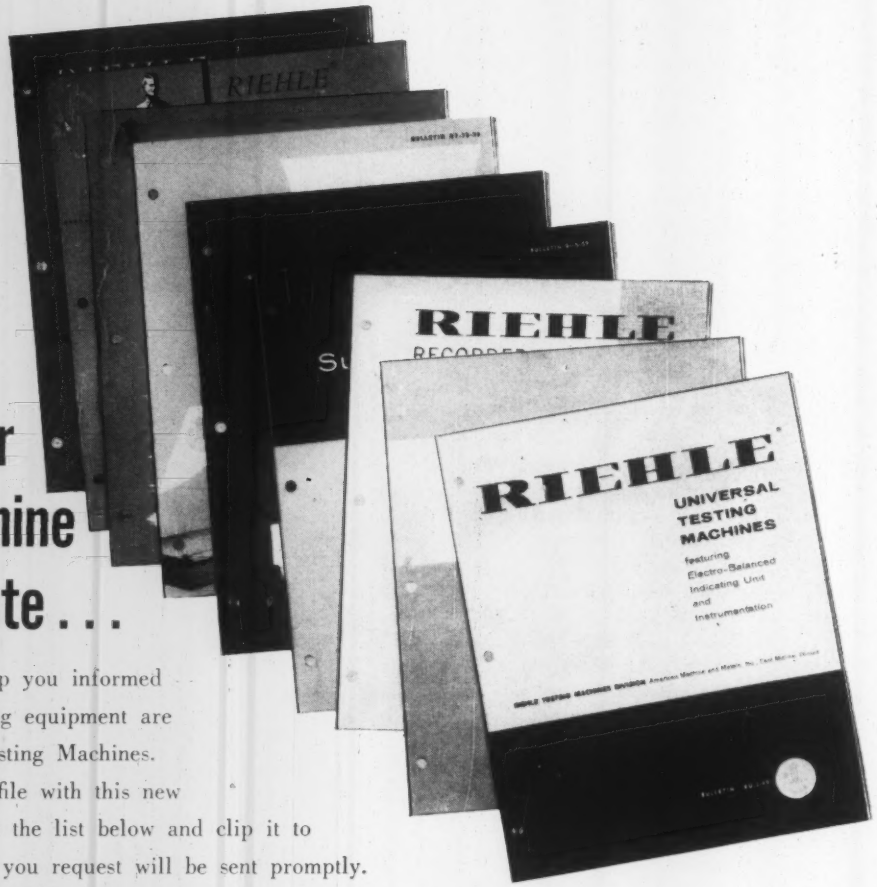

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For more information, turn to Reader Service card, circle No. 320

ISO Committee Pushes Plastics Standards

Significant progress was made toward simplifying and increasing international plastics standards by the International Standards Organization's Technical Committee on Plastics (ISO/TC 61) in its recent meeting in Prague, Czechoslovakia.

Standards essential to trade

Keener competition for American industry, particularly from the European common markets, make the ISO standards necessary tools for competing on a par with other nations. They are also important factors in designing mutual defense systems under NATO, and in the exchange of technical knowledge.

The Technical Committee on Plastics is the most productive of the 97 ISO groups dealing with the whole range of standards. It is also the committee in which this country is most active. (Details of the committee's organization were reviewed in M/DE, Jan '59, p 177. Also see p 166 in this issue for comment on the U.S. role in international standards activity.)

At the Prague meeting 113 delegates from 15 nations approved for ballot three more methods of testing plastics: 1) torsion stiffness as a function of temperature, 2) maximum temperature and rate of rise during setting of unsaturated polyesters, and 3) tensile stress-strain properties. These make 36 draft recommendations sanctioned by TC 61 for final preparation as international standards.

Five more ISO plastics recommendations were published during 1960, bringing to nine the total in the plastics field.

New definitions, tests, groups planned for 1961

▸ Lists of definitions in the official ISO languages — English, French, Russian—will be drafted for next year's meeting. Such literal definitions, the first of their kind, are expected to help enormously in trade and technical exchanges. The list will augment the compilation of 800 equivalent terms that is scheduled for ISO action in 1961.

▸ National standards for tensile impact testing, indentation hardness, and alternating flexural hardness will be circulated for study.

▸ A new group on cellular plastics will be formed under U.S. leadership. Its first job will be to outline problem areas and propose appropriate means for characterizing cellular plastics in commerce. The group will be closely coordinated with the cellular rubber group.

News of Societies

American Institute of Mining, Metallurgical, and Petroleum Engineers has awarded Thomas E. Millsop of National Steel Corp., the Benjamin F. Fairless Award for continuing technical progress in the industry.

Cast Bronze Bearing Institute has elected the following officers for 1960-61: president—C. N. Paden, Moccasin Bushing Co.; vice-president — A. G. Eberle, Renewal Service, Inc.; secretary-treasurer—R. O. Oyler, Bunting Brass & Bronze Co.

Engineers Joint Council has elected the following officers: president—J. N. Landis, Bechtel Corp.; vice-president — G. E. Holbrook, E. I. du Pont de Nemours & Co.

National Castings Congress & Exposition of the American Foundrymen's Society has chosen S. D. Russell of Phoenix Iron Works as chairman of the host chapter convention committee.

Society for Nondestructive Testing has chosen Charles D. Moriarty of General Electric Co. to deliver the Mehl Lecture at its 20th Annual Meeting.

Society of Plastics Engineers has announced the following 1961 officers: president—F. W. Reynolds, International Business Machine Corp.; vice-president—J. R. Lampman, General Electric Co.; secretary—M. F. Malone, Canadian Resins & Chemicals Co.; treasurer—J. Berutich, Haveg Industries.

Society of the Plastics Industry Inc., Cellular Plastics Div., has reelected Dr. S. Steingiser, Mobay Chemical Co., and E. A. Edberg, of Koppers Co. Inc., as chairman and vice-chairman respectively.

Metal Powder Parts Competition

The second annual competition for nonferrous metal powder parts has been announced by the Metal Powder Industries Federation.

Awards of $500 will be made to both the product manufacturer and the fabricator who submit the winning entry made of brass, nickel silver, or prealloyed bronze powder. Entries can be a product, component or assembly made after Jan 1, 1960 or one that will be in production by Feb 28, 1961, the day the contest closes.

Entry blanks and information can be obtained from the Awards Editor, Metal Powder Press, 160 Front St., New York 38, N. Y.

Research Programs on Materials

▸ New or improved techniques for mill rolling and hot extruding beryllium into structural shapes is the goal of a $300,000 research and development contract awarded to Beryllium Corp. by the Air Force.

▸ Better materials for the electrical industry will be developed by the research laboratory being built in Fort Wayne, Ind. by Rea Magnet Wire Co., a subsidiary of Aluminum Co. of America.

▸ High temperature research on inorganic chemicals, ceramics, metals and minerals will be conducted in the new laboratory of Metal & Thermit Corp. Rahway, N. J. It is designed primarily for problems starting at 350 F and up.

Coming Meetings on p 25 ⟶

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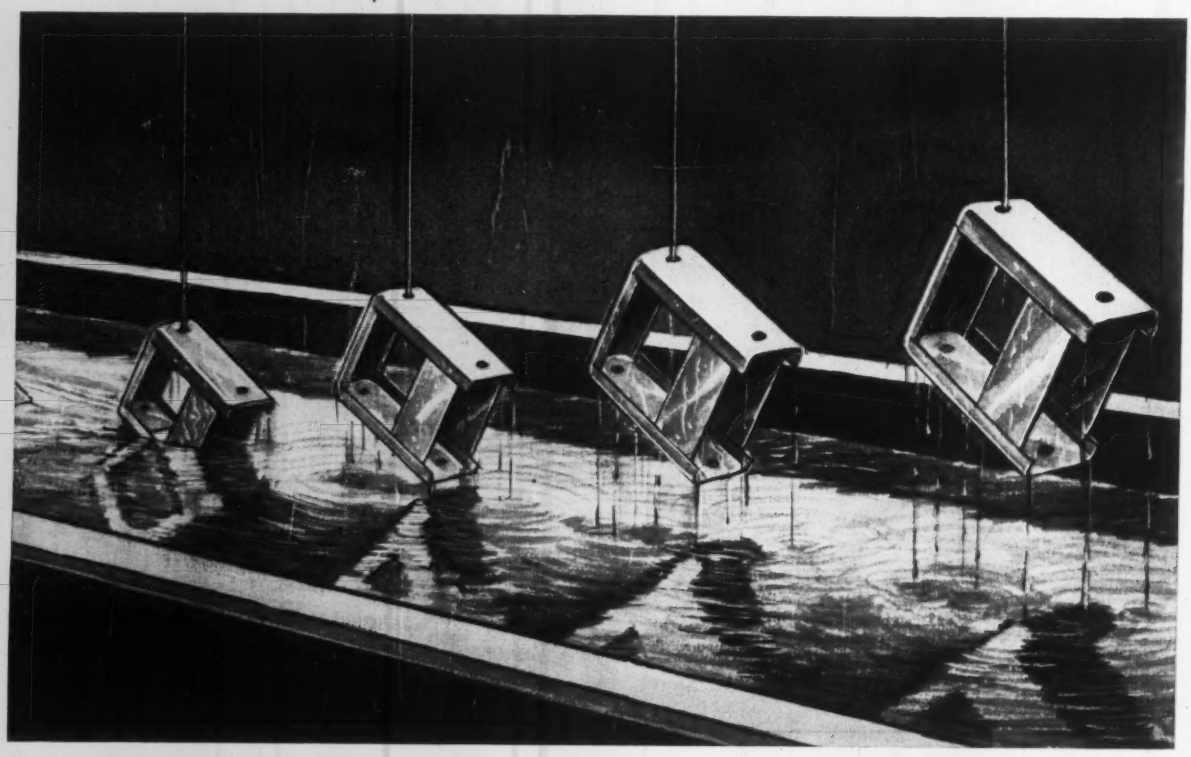

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Coming Meetings

3RD MECHANICAL WORKING CONFERENCE, "Bar & Shaped Products," American Institute of Mechanical Engineers. Pittsburgh. Jan 18.

SOCIETY OF PLASTICS ENGINEERS, 17th annual technical conference, Baltimore-Washington Sec. Washington, D.C., Jan 24-27.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Cincinnati. Jan 30-Feb 3.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 16th Reinforced Plastics Div. Conference. Chicago. Feb 7-9.

AMERICAN INSTITUTE OF MINING, METALLURGICAL & PETROLEUM ENGINEERS, annual meeting. St. Louis. Feb 19-23.

TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY, 46th annual meeting. New York City. Feb 20-23.

AMERICAN INSTITUTE OF MECHANICAL ENGINEERS, annual meeting. St. Louis. Feb 26-Mar 2.

GAS TURBINE POWER CONFERENCE & EXHIBIT, American Society of Mechanical Engineers. Washington, D.C. Mar 5-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, 59th annual meeting. Chicago. Mar 11-14.

AVIATION CONFERENCE, American Society of Mechanical Engineers. Los Angeles. Mar 12-16.

TEXTILE ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Clemson, S. C. Mar 16-17.

AMERICAN SOCIETY FOR METALS, 12th Western Metal Congress & Exposition. Los Angeles. Mar 20-24.

INSTITUTE OF PRINTED CIRCUITS, 3rd annual meeting. New York City. Mar 21-22.

AMERICAN CHEMICAL SOCIETY, 139th national meeting. St. Louis. Mar 21-30.

PRESSED METAL INSTITUTE, spring technical meeting. Cleveland. Mar 22-24.

FILAMENT WINDING CONFERENCE, Society of Aerospace Material & Process Engineers. Pasadena. Mar 28-30.

MATERIALS FOR ELECTRON TUBES AND SEMICONDUCTOR DEVICES, American Society for Testing Materials. Philadelphia. Apr 5-7.

MANAGEMENT ENGINEERING CONFERENCE, American Society of Mechanical Engineers. New York City. Apr 6-7.

OIL & GAS POWER CONFERENCE & EXHIBIT, American Society of Mechanical Engineers. New Orleans. Apr 9-13.

Reevecote broadens use of popular air switch with stronger— more sensitive diaphragms

T. H. Landgraf, Chief Engineer at The Autogas Company of Bellwood, Illinois, says: "The use of a Reevecote diaphragm allows a wider range of control of all kinds of gases, wider temperature range and provides greater strength."

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Ferrous castings manual contains errors

To the Editor:

I read with interest the manual "Guide to Ferrous Castings" (M/DE, Oct '60, pp 127-142). However, there was one startling comparison that seems very open to question. I refer to the comparison between gray and malleable irons presented in Fig 11 which shows 14.5 ft-lb Charpy impact at room temperature for gray iron, but only 4 ft-lb for malleable iron. Obviously, something is wrong here because gray irons have no practical impact strength, while malleable irons are known for their shock resistance. Gray iron in the form of standard 0.394-in. square Charpy specimens would normally have less than 2 ft-lb, while malleable iron should have some 16 ft-lb.

Also, the composition listed for malleable iron seems to be very abnormal, in that the total carbon content was 3.05%. According to the Malleable Founders' Society, total carbon range is 2.00-2.65%.

GORDON B. MANNWEILER
Chief Metallurgist
Eastern Malleable Iron Co.
Naugatuck, Conn.

Mr. Mannweiler is correct that the impact strength of malleable iron should be about 16 ft-lb, rather than 4 ft-lb. However, the gray irons currently being produced do have definite impact strengths and can no longer be classified as completely brittle materials. The 14.5 ft-lb quoted for gray iron is approximately correct. As far as total carbon content of malleable iron is concerned, reader Mannweiler is again correct that a maximum of 2.65% should be expected.

To the Editor:

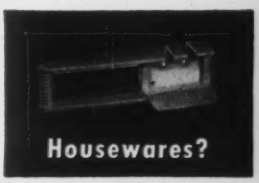
I should like to commend you for your interesting and timely manual on ferrous castings. It is obvious that a great deal of thought, hard work and cooperative effort went into the preparation of this treatise, which will, no doubt, become part of the permanent reference file of many engineers, metallurgists and purchasing agents.

There are a few comments, however, that I would like to make:

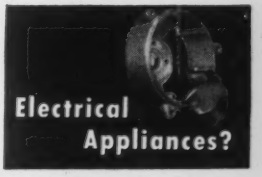
1. Tables 1 and 3 do not agree with respect to minimum specifications for malleable iron. For example, compressive strengths in excess of 250,000 psi have been reported and they would certainly be expected to be at least equal to values for gray iron.

2. The most unfortunate error involves impact properties of different ferrous metals. Part of the trouble is due, I am sure, to the outlandish composition of the quoted so-called malleable iron, which is not representative at all.

3. The magnetic properties of malleable iron were omitted entirely in your discussion of magnetic properties of ferrous castings. This creates the impres-



What are your zinc or aluminum



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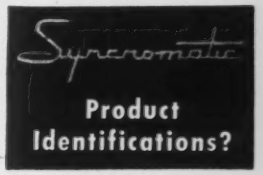

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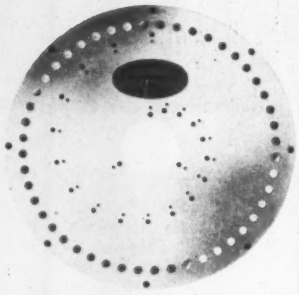

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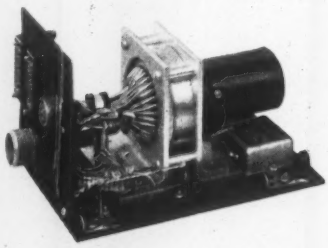

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. . . in 1955, MYCALEX CORPORATION OF AMERICA formed the Synthetic Mica Company and opened the first plant in the world for commercial production of synthetic mica—freeing America from any threat of a critical mica shortage in war or peace. Now industry and the military are assured an adequate supply of this critical and basic material.

An intensive and diversified Research and Development Program is carried on by MYCALEX CORPORATION OF AMERICA at its technical center located at the Synthetic Mica Company facility. This broad scale program is constantly developing new manufacturing techniques and materials to supply the ever-increasing demands and rigorous requirements of the electronics and allied industries.

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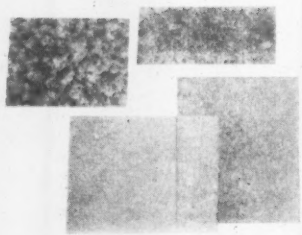
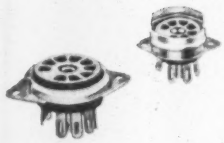
And other synthetic mica formulations . . . for use up to 1832°F.



MYCALEX TUBE SOCKET CORPORATION

. . . produces a superior line of miniature and subminiature tube sockets and transistor sockets, precision-molded of glass-bonded mica and ceramoplastic. These advanced components feature close tolerances, low dielectric loss with high dielectric strength and high arc resistance. They exhibit high dimensional stability over wide humidity and temperature ranges.

TUBE SOCKETS TRANSISTOR SOCKETS



Engineering and Design Assistance

From its inception, MYCALEX CORPORATION OF AMERICA has maintained a staff of experts in the production and engineering of electrical and electronic insulating materials. Their experience includes both commercial and military projects, and present activities encompass both applied research and product development. Mechanical and chemical skills are available to assist customers in the design and evaluation of components for virtually all insulating purposes. You are cordially invited to make use of these and our other services, established for your convenience.

General Offices and Plant: 122 Clifton Blvd., Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

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MYCALEX
CORPORATION OF AMERICA

World's largest manufacturer of glass-bonded mica, ceramoplastic and synthetic mica products

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sion that gray irons have superior characteristics in this respect. The exact opposite is the case! Whereas annealed flake graphite cast irons have a maximum permeability of 680, the value for malleable iron is 2140. Coercivity is less than one-tenth that of gray iron.

HANS J. HEINE
Technical Director
Malleable Founders Society
Cleveland, Ohio

On the other hand . . .

To the Editor:

May I congratulate you on the publication of this excellent review of the main factors in the production and use of ferrous castings. Anyone who takes the time to read this manual should certainly be able to improve castings produced as well as find the proper application for castings . . .

L. C. DUBS
President
Canton Pattern & Foundry Co.
Canton, Ohio

To the Editor:

Please send me thirty copies of the reprint "Guide to Ferrous Castings." The ten previously received have been too few—the requests for that excellent bit of writing and data by my foundry customers and friends, along with their most favorable comments, were very pleasing to me.

CHARLES L. HUETHWOHL
Rocky River, Ohio

Price of nickel powders

To the Editor:

The price of nickel powders was shown incorrectly in the price charts published on pp 215-220 of the Sept '60 issue. The price should be 74-79¢ per lb in carload quantities.

JOHN W. DONAHEY
General Manager
Public Relations & Advertising
Foote Mineral Co.
Philadelphia, Pa.

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ROBERT L. EWING
Weights Engineer
Missile and Space Vehicle Dept.
General Electric Co.
Philadelphia, Pa.

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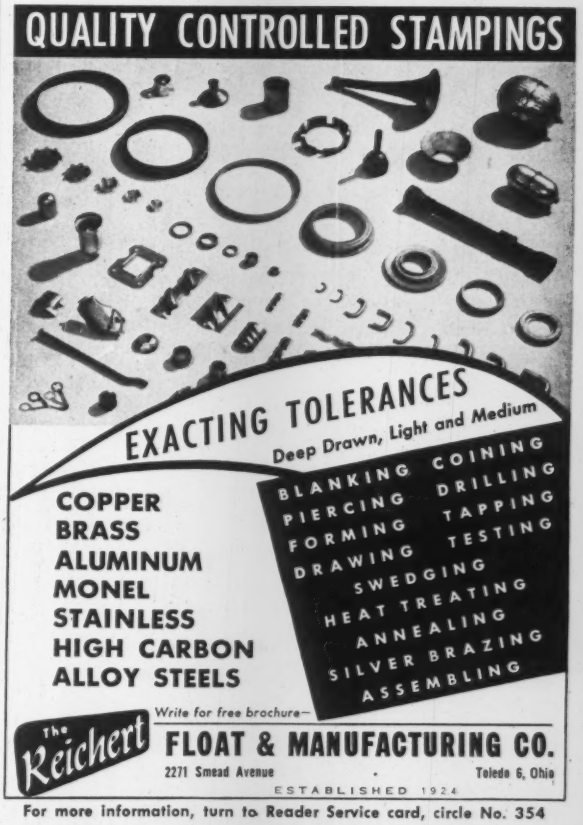

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PHOTO MATERIAL COURTESY OF WOODALL INDUSTRIES, INC.

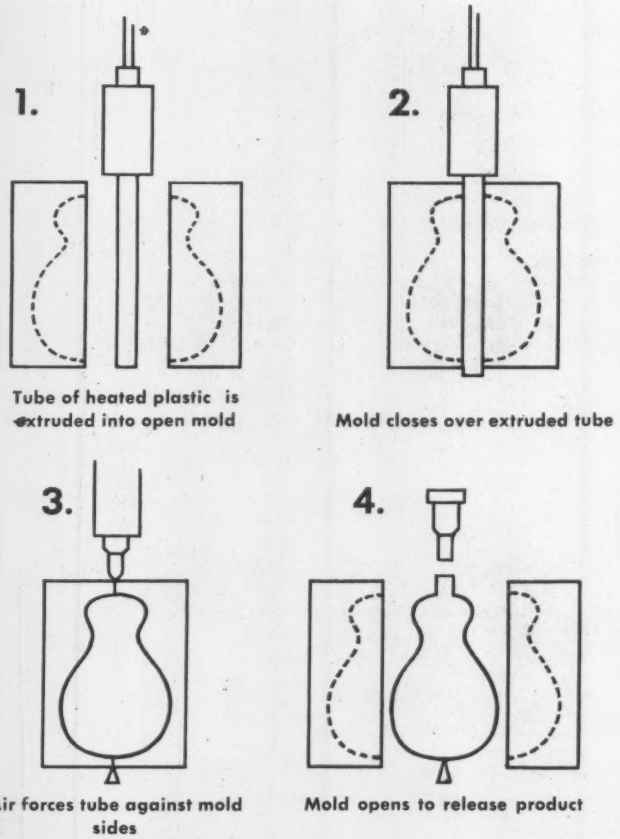
The auto industry warms up to blow-molded polyethylene

These complex shapes you see are sections of heater ducts for Chrysler Corporation cars, blow molded of BAKELITE Brand high-density polyethylene. Each part is made in *one piece*. These components must fit together easily and precisely, yet this method produces them economically. They are tough and light-weight, characteristic of the material from which they are made. They show the designer new sizes and shapes he can now work with in polyethylene.

BLOW MOLDING PUTS BIG DESIGNS

Blow molding is economical

Economy is a major advantage of the blow molding process. All you need is the mold cavity; the core is air pressure itself. Essentially, the operation begins when an extruded tube of heated plastic is placed within the two halves of a mold. An air blast into the tube forces it out against the mold, which is then opened, allowing the blown piece to be removed. Since air pressures seldom exceed 80 psi, molds can be made from low-cost materials and tooling up is fast. The plastic is formed at relatively low temperatures. That means faster cooling. Refinements of the basic process allow cost-cutting automation. Even injection molding equipment can be adapted to the process for special requirements.



Tube of heated plastic is extruded into open mold

Mold closes over extruded tube

Air forces tube against mold sides

Mold opens to release product

50% cost reduction was just one of the benefits...

This traffic blinker housing is two feet long. It, too, is made in *one piece* by blow molding high-density polyethylene. Any other technique would have required a two-piece assembly. Previously constructed from sheet metal stampings, it required not only assembly but a separate coating operation as well. Blow molding saves 50% of former production costs! Molds can be made quickly and inexpensively. The color is molded in. BAKELITE Brand high-density polyethylene also gives the product lightness, rigidity, and durability.

IN PLASTICS

Since participating in the development of the squeeze bottle, Union Carbide has been refining the techniques and materials for blow molding. Facilities for studying production-line blow molding at the Bound Brook, N. J., laboratories are unsurpassed. A battery of blow molding machines there reproduces every set of conditions encountered in the process. This equipment, in addition to providing basic knowledge about blow molding, helps in developing new BAKELITE Brand polyethylenes—high-, medium-, and low-density, and copolymers. You can select from the greatest variety available at one source, confident of getting the formulation best suited to your needs.

For information on application of these materials and processes to your products, write Dept. ID-85, Union Carbide Plastics Company, Division of Union Carbide Corp., 270 Park Ave., New York 17, N. Y. *In Canada,* Union Carbide Canada Limited, Toronto 12.

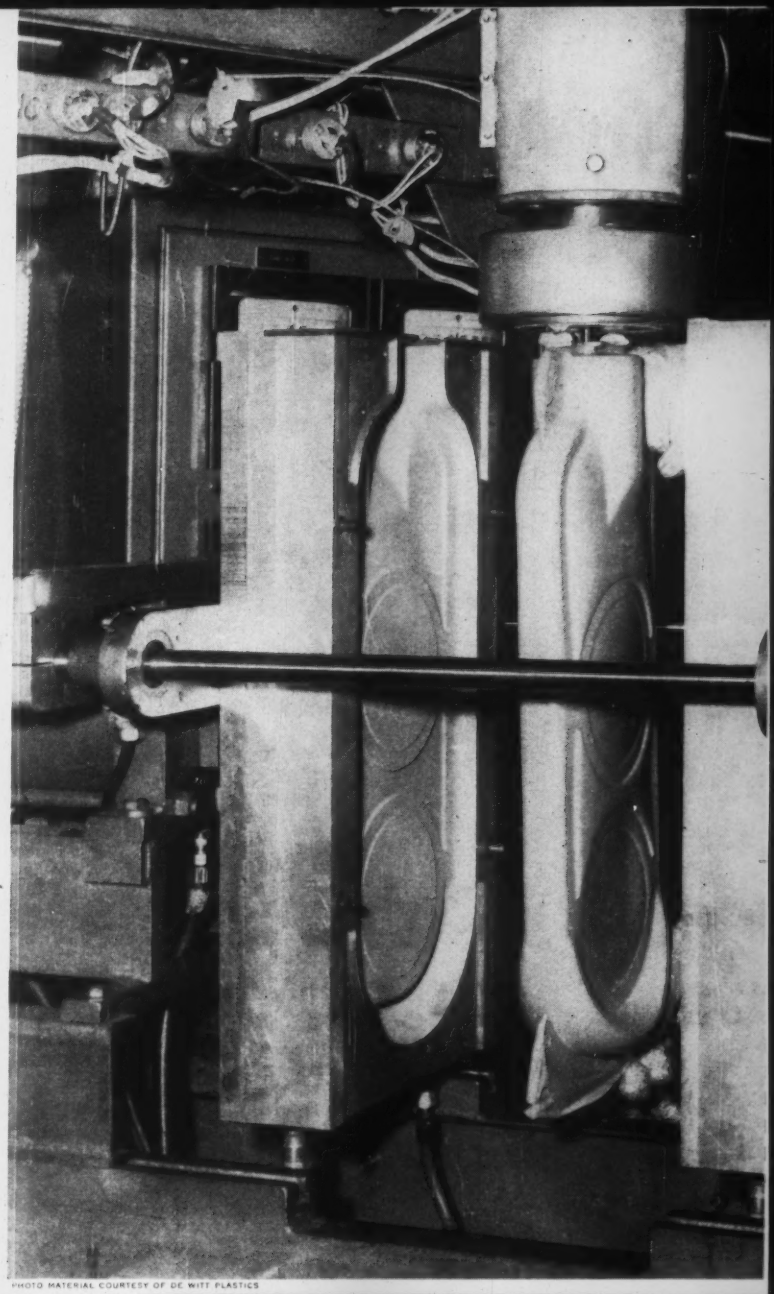
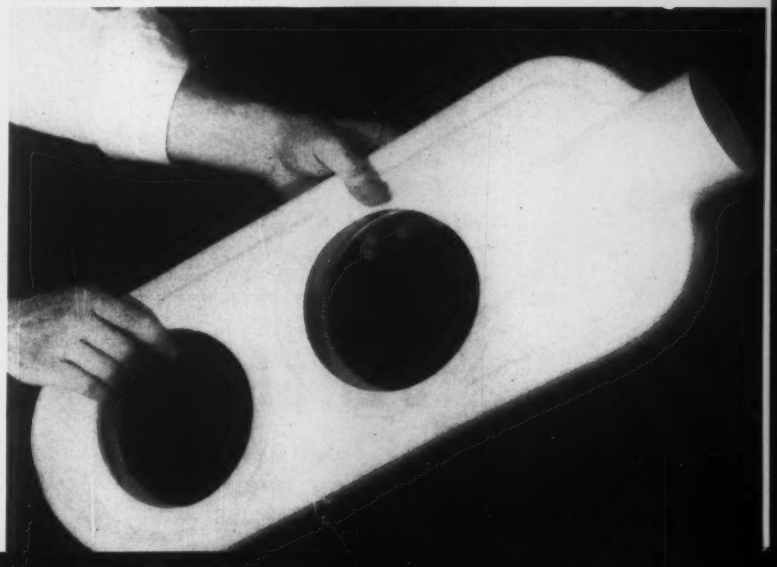


PHOTO MATERIAL COURTESY OF DE WITT PLASTICS



UNION CARBIDE

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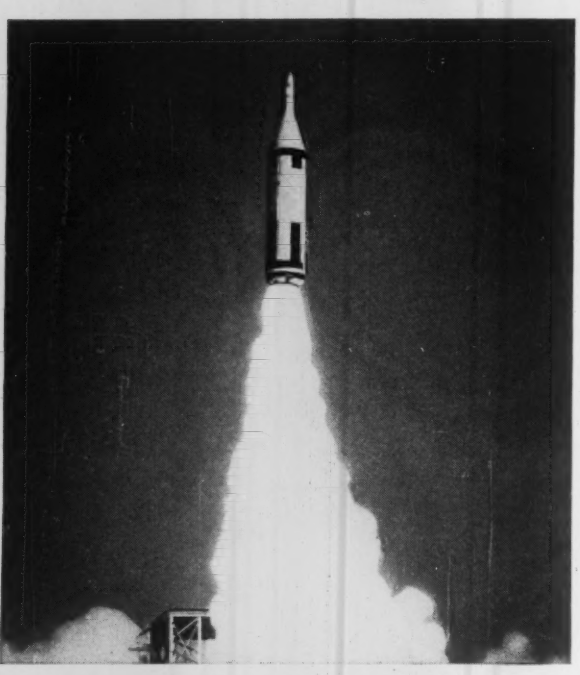
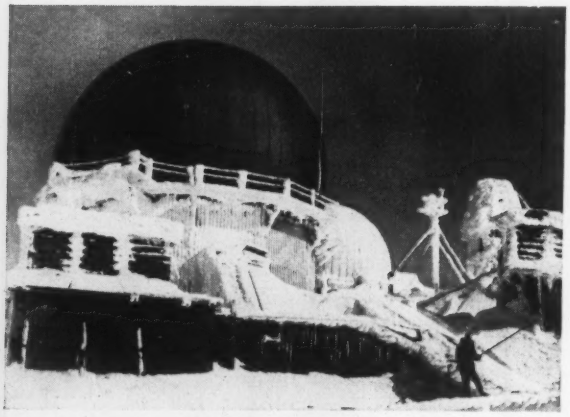
In Arctic cold...



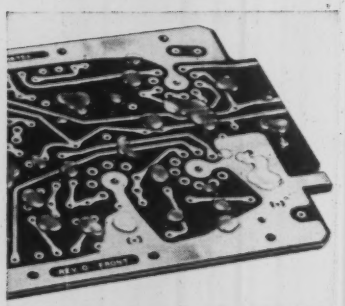


General Electric Silicone Fluids offer reliability from —65°F to 400°F as liquid dielectrics and heat transfer media in aircraft, missiles and ground installations. Excellent dielectric properties are virtually unchanged over wide ranges of temperature and frequency.

or missile heat...

G-E Silicone Rubber Insulation is used in missiles and space vehicles because of its excellent insulating properties, resistance to temperature extremes, moisture and ozone and its long-time stability in storage.

G-E silicone insulations do the job!



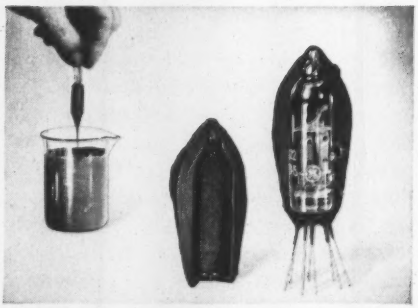
RTV* Liquid Silicone Rubber comes in a wide range of viscosities for potting, encapsulating, impregnating and sealing. RTV resists heat, cold, ozone, moisture; protects against high-altitude arc-over.
*Room Temperature Vulcanizing

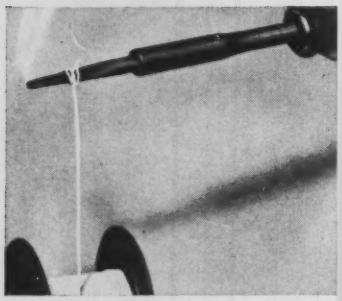
G-E Silicone Varnishes provide excellent protection against moisture and high operating temperatures. Applications include conformal protective coatings for printed circuits, resistor coatings, transformer impregnation, etc. New varnishes cure at low temperatures.

New Silicone Dielectric Greases maintain physical and electrical properties from —65°F to 400°F, offer protection against moisture and oxidation. Used as corrosion inhibitors, lubricants, heat transfer media and release agents.

Silicone Rubber Wire Insulation withstands soldering heat without damage; matches or exceeds vital properties of insulation costing three times as much. Provides long service life at 500°F; momentarily withstands temperatures up to 5500°F. Flexible as low as —150°F, it resists moisture, ozone, nuclear radiation.

Send for technical data, "Silicones-for-Insulation." Section B-131, Silicone Products Department, Waterford, New York.





GENERAL ELECTRIC

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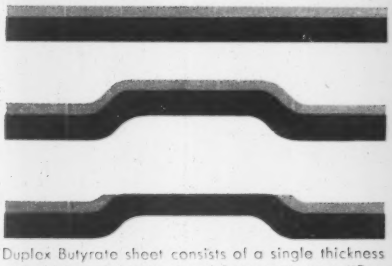
Here's news about Butyrate plastic...

Duplex Butyrate sheet yields 2-color signs that by-pass usual decorating...the sheet itself provides the second color

Duplex sheet is formed in the same manner as regular Butyrate sheet for signs.



Duplex Butyrate sheet consists of a single thickness with thick and thin layers of Butyrate in two different colors.

The versatility of Tenite Butyrate as a plastic material for signs gains added recognition with the development of duplex sheet. By taking advantage of the ingenious construction of this new sheet, the creative sign designer and sign builder can produce 2-color effects without use of lacquers or inks.

In essence, duplex Butyrate plastic sheet consists of a heavy layer of one color under a thin layer of a second color. The sheet is produced by extruding and laminating one layer of colored plastic directly upon another layer of a different contrasting color. For example, a duplex sheet for forming a representative 4- by 6-foot sign panel might have a heavy layer 0.090-inch thick and a thin layer 0.010-inch thick.

After the sheet has been formed into a sign panel or element, with the thin layer on the appearance side, the color of the heavy layer may be quickly exposed by sanding away the thin layer from the raised surfaces of the sign face. The choice of color combinations will be determined by the effects desired, the specific application, the use (or the non-use) of backlighting, and the esthetic preference of the individual sign designer.

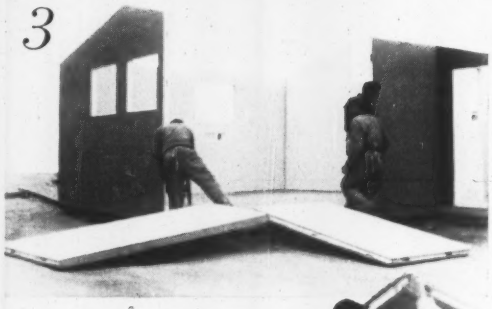
For information on availability of duplex Butyrate sheet, write to the Plastics Division, EASTMAN CHEMICAL PRODUCTS, INC., KINGSPORT, TENNESSEE, or to the sales office nearest you.

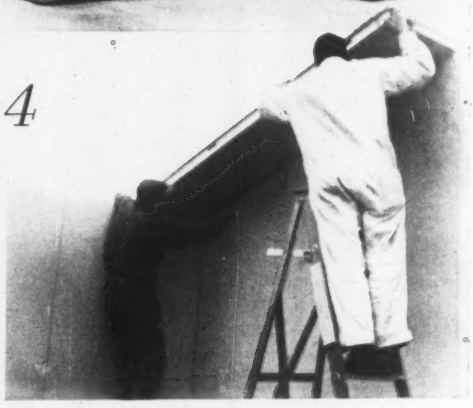
After forming, the thin layer of color is sanded away from certain raised areas to expose the second color underneath.

TENITE®
BUTYRATE
an Eastman plastic

For more information, circle No. 413

how to build a house in a day...





1 Floor panels are locked to joists laid on permafrost ground.

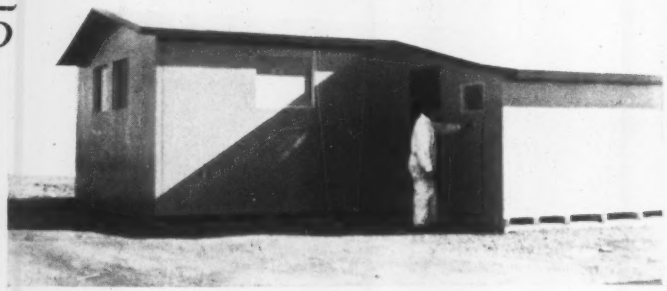
2 Doorway is first wall panel to go up. It locks to floor.

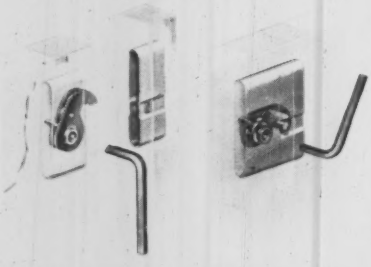
3 Walls and partitions lock to floor and to each other.

4 Roof panels go on last. This takes about three hours.

5 Complete in 7 hours! Floor, walls, roof panels—It's all done with Simmons Dual-Lock fasteners.

Standard Dual-Lock withstands 2500-lb. tension; may be modified for high-load applications to 4500 lbs.





■ This house is put up in a day — and can be taken down in half a day!

■ Key to quick assembly-disassembly is the Simmons Dual-Lock.

Dual-Lock is a high-load, positive-locking structural fastener perfectly adapted to panel fastening of demountable shelters, shipping containers, covers, cowlings... and to all butt-joint fastening jobs. It can be recess-mounted as in the application pictured, or surface-mounted on sheets or panels. Locks with heavy closing pressure, with very light pressure required on the key.

Arctic Units, Ltd., Toronto, Canada, is putting up 90 "Eskimo Houses" on the DEW Line. Panels, including roof, are plywood-covered styrofoam designed for insulation against Arctic cold.

WRITE FOR CATALOG 760. Complete details of Dual-Lock and other dependable quick-operating Simmons Fasteners with unlimited money-saving applications.

■ Samples and engineering service available upon request.

SIMMONS FASTENER CORPORATION

1759 North Broadway, Albany 1, New York

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Magnet wire resists 500 F	19	608
Alloy steel for anti-smog devices	122	614
Tungsten formed by high energy process	134	621
PLASTICS & RUBBER		
Data on polyester film for packaging, other uses	15	602
Polyethylene resin has good crack resistance	128	618
Polystyrene sheet for lighting applications	136	623
Bondable Teflon-FEP film	140	625
Filled silicone rubber	150	632
OTHER NONMETALLICS		
Titanium diboride parts	10	600
Decorative asbestos sheets	124	615
High strength alumina for metallizing	130	619
Glass-bonded mica has smooth finish	158	637
FINISHES, COATINGS		
New organic coatings	17	604 to 607
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3	28	53	78	103	128	153	178	203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678
4	29	54	79	104	129	154	179	204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679
5	30	55	80	105	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680
6	31	56	81	106	131	156	181	206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681
7	32	57	82	107	132	157	182	207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682
8	33	58	83	108	133	158	183	208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683
9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
11	36	61	86	111	136	161	186	211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686
12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687
13	38	63	88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688
14	39	64	89	114	139	164	189	214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689
15	40	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690
16	41	66	91	116	141	166	191	216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691
17	42	67	92	117	142	167	192	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692
18	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693
19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
20	45	70	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
21	46	71	96	121	146	171	196	221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696
22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700

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Impact Thermoplastics	686
Die Castings	685
Adhesive Bonding	684
Guide to Spring Materials	683
Guide to Industrial Textiles	682
Physical Properties and Tests	681
Designing with Metal Powder Parts	680
Organic Coatings for Metal Products	679
Guide to Plastics Selection	678
How to Select a Stainless Steel	677
Sheet Formed Plastics Parts	676
Sleeve Bearing Materials	675
Designing Metal Stampings	674
Paper as an Engineering Material	673
Porcelain Enamels, Ceramic Coatings	672
Designing with Heat Treated Steels	671
New Developments in Ceramics	670
Thermal Insulation Materials	669

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TECHNICAL LITERATURE

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TECHNICAL LITERATURE

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Vinyl Resins. Goodyear Tire & Rubber Co., Chemical Div., 4 pp. Properties and uses for medium and low viscosity, general purpose vinyl resins. **111**

Thermoplastic Coil Bobbins. Gries Reproducer Corp., 2 pp, illus., No. 3003. Sizes, advantages and characteristics of coil bobbins precision molded from nylon, acetal, CFE and other plastics. Included is a chart on electrical properties of nylon. **112**

Silicone Rubber. Haveg Industries, Taunton Div., 6 pp, illus. Information on molded, extruded and die cut silicone rubber parts. **113**

Polycarbonate Plastics. Mobay Products Co., Merlon-Polycarbonate Resins Div., No. TIB-41-M1. Physical and electrical properties, and typical uses of polycarbonate plastics. **114**

Vinyl On Metal. Monsanto Chemical Co., Plastics Div., 20 pp, illus. Advantages, characteristics, and uses of vinyl-coated metal parts. **115**

Machining Laminates. National Vulcanized Fibre Co., 4 pp, illus. Information on how to saw, sheer, slit, punch, drill, tap and thread, turn, bore, face, and mill glass-base plastics laminates. **116**

Perforated Rubber, Fabrics. Perforating Industries, Inc., 16 pp, illus., No. 57. Information on perforating, slitting and blanking of coated fabrics, plastics, rubber, hides, felt, paper, fabrics, foam rubber and imitation leather. **117**

Rigid Polyethylene Plastics. Phillips Chemical Co., Plastic Sales Div., 26 pp, illus. Properties, uses and fabricating data for rigid polyethylene resins. **118**

Machining TFE. Raybestos-Manhattan, Inc., Plastic Products Div., 12 pp, illus., No. 0701. Stress relieving; tools and coolants; speeds and rates of feed; rakes, angles, and clearances; turning, boring, drilling, tapping, reaming, counter boring, and grinding; tolerances; and other information on machining TFE plastics. **119**

Polystyrene. Shell Chemical Corp., Plastics & Resins Div., 2 pp. No. SC-60-100. Information on facilities and services available for the production of polystyrene compounds for molding, extruding, and vacuum forming. **120**

Fabricating Plastics Parts. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for injection molding, vacuum distillation plating, hot stamping, painting and assembly of plastics parts. **121**

Vulcanized Fibres. Spaulding Fibre Co., 44 pp, illus. Properties, uses and specifications of vulcanized fibres and thermosetting plastics. **122**

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Rubber Stocks. Stalwart Rubber Co., 16 pp, illus. Information on type of rubber stocks from which company fabricates precision parts. **124**

Laminated Plastics. Synthane Corp., 8 pp, illus., No. FF 560. General information on the facilities and services available for the production of industrial thermosetting laminated plastics. **125**

Epoxy Resin System. Thiokol Chemical Corp., illus. Physical properties and uses of a liquid polymer epoxy resin system for use as coatings, adhesives, and potting and casting compounds. **126**

Plastics Pipe. National Tube Div., U. S. Steel Corp., 28 pp, illus., No. 24. Data on unplasticized rigid polyvinyl chloride pipe, both normal and high impact types. **127**

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Cemented Carbides. Allegheny Ludlum Steel Corp., Carmet Div., 12 pp. Design techniques, physical and mechanical properties, hardness, abrasion resistance, available sizes, and other information on the selection and use of cemented carbides. **128**

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eral description; composition; advantages; physical, electrical and mechanical properties; and prices of boron nitride ceramics. **131**

Felt. Continental Felt Co. Information on wool, synthetic fiber and colored felts. **132**

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Carbon and Graphite. Stackpole Carbon Co., 54 pp, illus., No. 40 C. Properties, and mechanical, chemical, electrical and refractory applications of carbon and graphite products. **142**

Finishes •
Cleaning & Finishing

Coating Resins. Allied Chemical Corp., Plastics & Coal Chemicals Div., 24 pp, illus. Properties and uses for oil-modified alkyd coating resins, urea and melamine coating resins, ester gums and pure phenolic resins. **143**

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Phosphate Conversion Coating. Amchem Products, Inc., 4 pp, illus., No. 1380A. General information on advantages, method of application and uses of a phosphate conversion coating for iron and steel. Included is a phosphate selection chart. **145**

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Multicolor Enamel. Maas & Waldstein Co., 2 pp, No. 520. Data sheet for industrial multicolor enamels. **153**

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Conversion Coatings. Parker Rust Proof Co., 4 pp, illus., Mar-Apr '60. Typical uses, characteristics and other information on a chemical conversion coating for aluminum. **156**

Industrial Gold Plating. Sel-Rex Corp., 8 pp, illus. Bath composition, equipment and operating conditions, and comparative metallurgical characteristics of an industrial gold plating used on various base metals. **157**

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Vinyl Coatings. U. S. Stoneware Co., Plastics & Synthetics Div., No. 187F-1. Chemical and moisture resistance, adhesive properties and application data for a vinyl coating that is applied by hot spraying. **159**

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Mechanical Fasteners. Chase Brass & Copper Co., 28 pp, illus., No. CK-17. Sizes, specifications, and other pertinent data on a line of bolts and nuts, cap and machine screws, washers, cotter pins, nails and tacks, escutcheon pins, rivets, etc. **161**

Epoxy Adhesive. Fybrglas Industries, 10 pp, illus. Advantages, characteristics, methods of application, typical uses and costs of a two-part epoxy resin adhesive system. **164**

Spiral Spacers. Huck Mfg. Co., 4 pp, illus., No. 8-659. Typical applications, required hand tools, installation data, suggested hole preparation, and other information on a universal-type spiral spacer for joining crushable panels to other parts or panels. **165**

Adhesive Selector Chart. Hysol Corp., No. A-100. Tensile shear strength at different temperatures, operating temperature ranges, Izod impact, coefficient of thermal expansion, and other criteria necessary for the selection of various adhesives and hardeners. **166**

Welded Assemblies. R. C. Mahon Co., 1 p, illus. Shows the use of welding in the construction of various assemblies. **168**

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, illus. Advantages and specifications of Spin-Lock screws available in hex, pan, truss or flat heads. **169**

Lock Nuts. Standard Pressed Steel Co., Industrial Fastener Div., 6 pp, illus., No. 2339. Advantages, characteristics, materials, finishes, size ranges, and other information on a line of self-locking nuts for industrial applications. **170**

Nylon Screws. Weckesser Co., 3 pp, illus. Installation data for black nylon screws and nuts. **172**

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• Testing

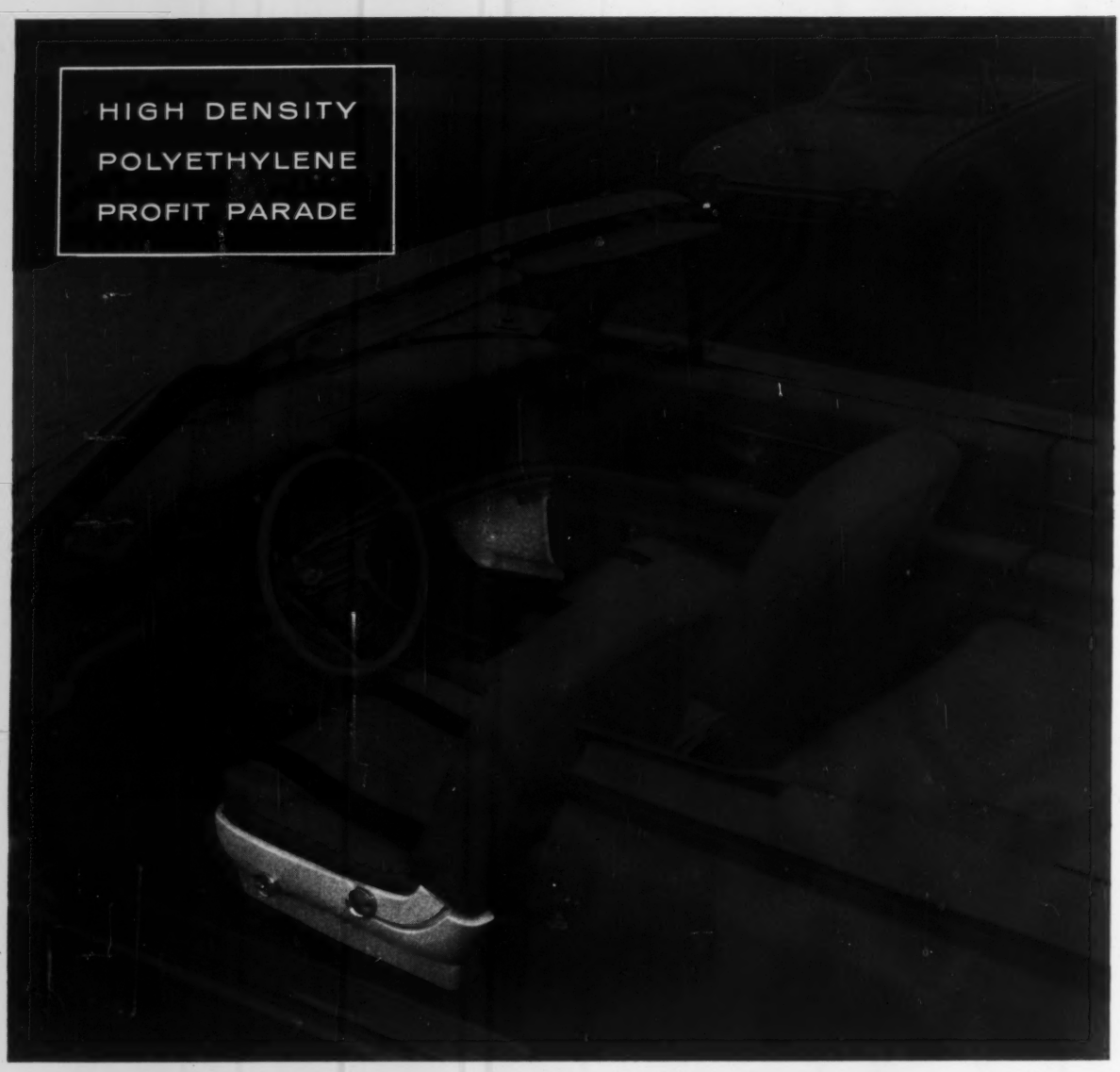
Universal Testing Machines. American Machine & Metals, Inc., Riehle Testing Machines Div., 40 pp, illus., No. RU-2-60. Advantages, characteristics, specifications, and other data on a line of universal screw power and hydraulic testing machines. **173**

Induction Heating. Lepel High Frequency Laboratories, Inc., 12 pp, illus., Vol. 1, No. 6. Information on the use of induction heating equipment in zone refining, zone leveling and crystal growing. **174**

Vacuum Furnaces. Kinney Mfg. Div., New York Air Brake Co., 28 pp, illus. Describes high vacuum furnaces for heat treating, annealing, brazing, melting, alloying and stream degasing of metals. **175**

Temperature Indicators. Tempil Corp., 1 p, illus., No. 5910TS. Information on a complete line of available temperature indicators, including instructions for use. Covers such things as checking temperatures of rotating parts, visibility on brightly radiating hot surfaces, and effects of reducing atmospheres in electrical fields. **179**

Turn to page 43 for current books and reports →



Grace Plastic Adds to Lasting Value of Classic Car

The beautiful, classic Thunderbird is a king in Ford Motor Company's famous line. And as befits a king, all its parts and appointments are made with special care, for lasting beauty, value and service . . . while maintaining realistic economies.

Example: Grex High Density Polyethylene is a material used in three "show" parts of this '61 model—in the side cowl cover, the side seat shield, and the pivot cap on the seats. Besides having smooth beauty, these parts also must be scuffproof. And they must be perfectly color-matched with other parts of the interior.

Grex is an excellent material for components such as these, where beauty, duty and economy of fabrication must go hand in hand. Grex can be formed by any conventional fabricating technique, in any color. It takes day-after-day punishment without chipping, cracking or breaking. It can undergo extremes of temperature without losing its strength or shape. And most important of all, it adds beauty and value to this car.

If you need the special advantages of high density polyethylene, don't overlook the experts. Grace has the production facilities, technical service and experience to help with demanding components problems. And we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins

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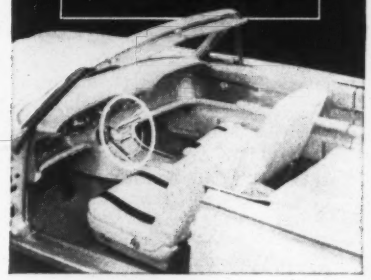


'61 Thunderbird sets
a standard for value.

Color is critical. As every auto buyer knows, cars are made in almost every color of the spectrum. Ford, in its Thunderbird line alone, uses 6 colors. Grex already has been supplied in all of these approved colors.

Matching colors to the most critical standards requires ingenuity, patience and experience. For colors must not only pass stringent visual tests under the Macbeth light, but must stand the test of time as well.

Wearing qualities essential. There would be little virtue to parts made of Grex if they merely appealed to the eye. All the parts are in "wear" locations, and are subject to scuffing or continual flexing. The problem of scuffing is overcome with a handsome, textured, leather-like effect. Scuffs literally "bounce off." This textured pattern was engraved in the irregular surface molds by photo arc.

The side cowl cover presented a special problem. It is thin-gauge, yet has large surface area. High density polyethylene was selected as the material for this part because it resists abrasion, withstands flexing, and has native toughness, even in very thin, large-area sections.

Why not use some other material? High density polyethylene has special advantages in applications like these. It requires no additional surface finish, and gives close color match. It has a warmth and solidity lacking in other materials. It doesn't chip, crack, or peel. Perhaps most important, it maintains economies while actually improving the quality look of components.

What about you? The problems present in this application can be applied profitably in other products. Luggage, for instance. And housewares, appliance components, quality toys. If you'd like a profitable answer to a high density polyethylene question, just write us:

Technical Service Department
Polymer Chemicals Division
W. R. Grace & Co., Clifton, N. J.

TECHNICAL LITERATURE

(cont'd from p 41)

Books

Handbook of Chemistry and Physics: 42nd Edition. *Edited by C. D. Hodgman, R. C. Weast and S. M. Selby. Chemical Rubber Publishing Co., Cleveland. 1960. Cloth, 5 by 7½ in., 3481 pp. Price $12*

The 42nd revision of this standard reference book reaffirms its claim to being the one invaluable source of information on practically every important area of mathematics, physics and chemistry.

The conveniently indexed volume, put together by over 200 recognized authorities, contains useful and accurate data in the following five general sections: 1) mathematical tables, including statistics, algebra and calculus; 2) properties and physical constants, including the elements, alloys, and organic and inorganic compounds; 3) general chemical tables, including specific gravity and properties of matter; 4) heat and hygrometry, including sound, electricity, magnetism, and light; and 5) quantities and units, including definitions, formulas and conversion tables.

New material added this year includes: diffusion of metals into metals; triple points and boiling points of low boiling elements; sublimation data; standard types of stainless steels; dissociation constants; and surface tension. Among the revised and up-dated data are atomic weights, trade names of plastics, and properties of refractory materials.

Chipless Machining. *Charles H. Wick. Industrial Press, New York. 1960. Cloth, 6 by 9 in., 502 pp. Price $10*

Subtitled "Methods of Cold Forming Ferrous Metals," this book describes 1) the essential steps involved in making parts by cold forming methods, 2) the design of equipment and tooling necessary for the use of each process, 3) typical applications, and 4) the economics of moving metal rather than removing it.

Specific topics covered include: metallurgical considerations of plastic deformation; coldheading; thread rolling; rolling of serrations; splines and gears; power spinning; rotary swaging; internal swaging; radial forging; cold forming of multiple diameter shafts; cold extrusion of steel; selecting materials and designing parts for cold extrusion; producing slugs and secondary operations; phosphate coating and lubricating for cold extrusion; die design for cold extrusion; and explosive and other high energy rate methods.

ASTM Books on Materials. *American Society for Testing Materials, Philadelphia.*

Fatigue of Aircraft Structures. *Special Technical Publication No. 274. 1960. Cloth, 6 by 9 in., 143 pp. Price $4*

This volume contains basic discussions of such topics as cumulative damage, crack propagation rates, and the effect of biaxial stressing, as well as general philosophies of design and test for spectrum-type loading, sonic fatigue, and high-stress, low-cycle fatigue.

Symposium on Treated Wood for Marine Use. *Special Technical Publication No. 275. 1960. Cloth, 6 by 9 in., 75 pp. Price $2.50*

Symposium on High Voltage Cable Insulation. *Special Technical Publication No. 253. 1960. Paper, 6 by 9 in., 44 pp. Price $1.50*

Particular emphasis is placed on materials requirements, their proper application, and test methods that will reveal the capabilities and faults of insulating systems used for extra high voltage transmissions. Subjects include: paper for high voltage cables; the why and how of cable oil tests, and the utility viewpoint on cable oils.

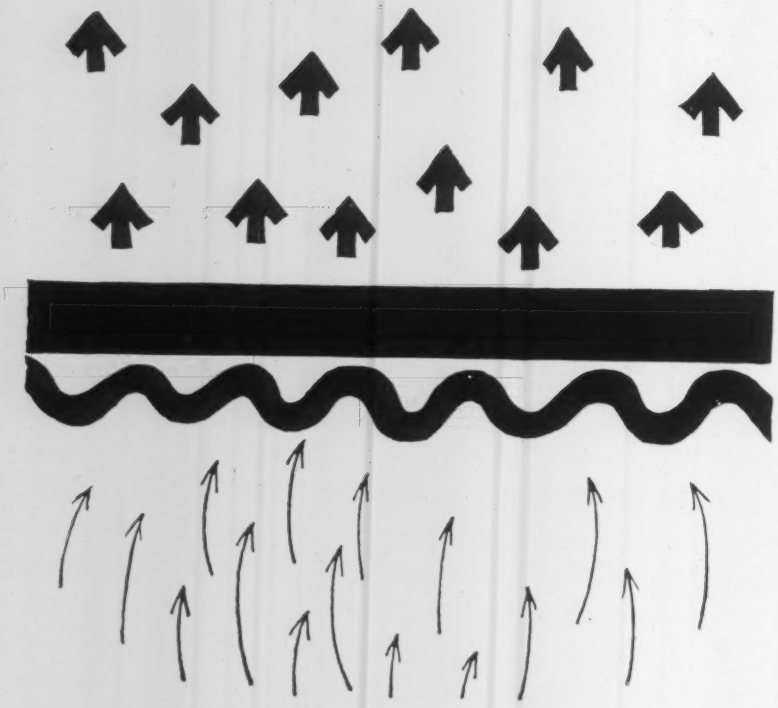
Stress-Corrosion Cracking of Austenitic Chromium - Nickel Stainless Steel. *Special Technical Publication No. 264. 1960. Paper, 8½ by 11 in., 96 pp. Price $6*

This report summarizes results of an extensive international survey of 145 cases of stress-corrosion cracking. The book is divided into two parts: 1) a review of the case histories; and 2) a description of the present status of research work. Some of the subjects covered are: identification of stress-corrosion, susceptible compositions, influence of heat treatment, surface finish, critical environments, corrosion, and preventive measures.

1959 References on Fatigue. *Special Technical Publication No. 9-K. 1960. Paper, 8½ by 11 in., 88 pp. Price $4*

Marine Atmosphere Exposure of Galvanic Couples Involving Magnesium. *Special Technical Publication No. 255. 1960. Paper, 6 by 9 in., 28 pp. Price $2.25*

Discusses results of exposure tests



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TECHNICAL LITERATURE

on protective systems for magnesium, including chromate conversion coatings, anodic coatings, and paint systems consisting of chromate primer and alkyd, phenolic and epoxy enamels.

Materials in Nuclear Applications. *Special Technical Publication No. 276. 1960. Cloth, 6 by 9 in., 350 pp. Price $8.25*

This is the most extensive volume ever published by ASTM in the nuclear energy field. Included in this one volume are papers presented at three different symposia: Radiation Effects and Dosimetry, postirradiation Effects in Polymers, and Ceramics in Nuclear Energy.

The symposium on Postirradiation Effects in Polymers contains four papers describing 1) some recent techniques for studying the identity, concentration, and lifetime of irradiated polymers; and 2) actual postirradiation changes in physical and chemical properties of a few selected polymer systems.

Reports

Dielectric Measurements A PRACTICAL INTERPRETATION OF DIELECTRIC MEASUREMENTS UP TO 100 MC. *211 pp. Available from Dept. of Commerce, Field Services, 350 Fifth Ave., New York 1, N.Y. Price $3.50*

An extensive investigation of the behavior of solid insulating materials over the frequency range of 60 cps to 100 mc. Purpose of the study was to determine the effects of frequency, temperature and moisture absorption on the electrical properties of representative insulating materials.

High temperature materials SYNTHESIS OF NEW HIGH TEMPERATURE MATERIALS. *J. L. Engelke and others, Stanford Research Institute. Feb '60, 44 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D.C. Price $1.25 (PB 161720).*

Describes an implosive-shock technique for synthesizing compounds that require high pressure to prevent thermal decomposition of metal. The technique is used to study a number of mixed transition metal carbides, borides and nitrides as a basis for the development of materials to withstand severe operating conditions at ultra high temperatures. The implosive technique is suitable where test materials are subjected to high temperature-pressure conditions for short periods.

AlSiMag® CRUSHABLE Ceramics

USE: These AlSiMag ceramics have a high volume resistivity at elevated temperatures. Excellent insulators for such applications as metal sheathed thermocouples, heaters, range units, metal sheathed cable, etc.

METHOD: The ceramics are usually supplied in short length, multiple hole, tubing. The thermocouple or heater wires or rods are inserted in the holes in the ceramic and this assembly is inserted in the metal sheath and swaged. Swaging shrinks the tube, crushes the ceramic which thus forms an accurately positioned, densely packed uniform insulation.

MATERIALS: AlSiMag 689 magnesia, high purity, high Te value. **AlSiMag 714** magnesia, extremely high purity, electrically fused. Particularly desirable for atomic energy applications. Meets purity requirements of AEC Spec. AEC-SR-101 (ORD) and KAPL Spec. O-KPM7-1. (Technical Data Sheets available on request.) **AlSiMag 730**, alumina oxide, extremely high purity.

SHAPES: These AlSiMag crushable ceramics can be made to individual specifications. Multiple hole tubing is most frequently used, normally in lengths of 1" to 4". Dimensional and technical data sheets on request. Send blue print or sketch and performance requirements where special designs are needed.

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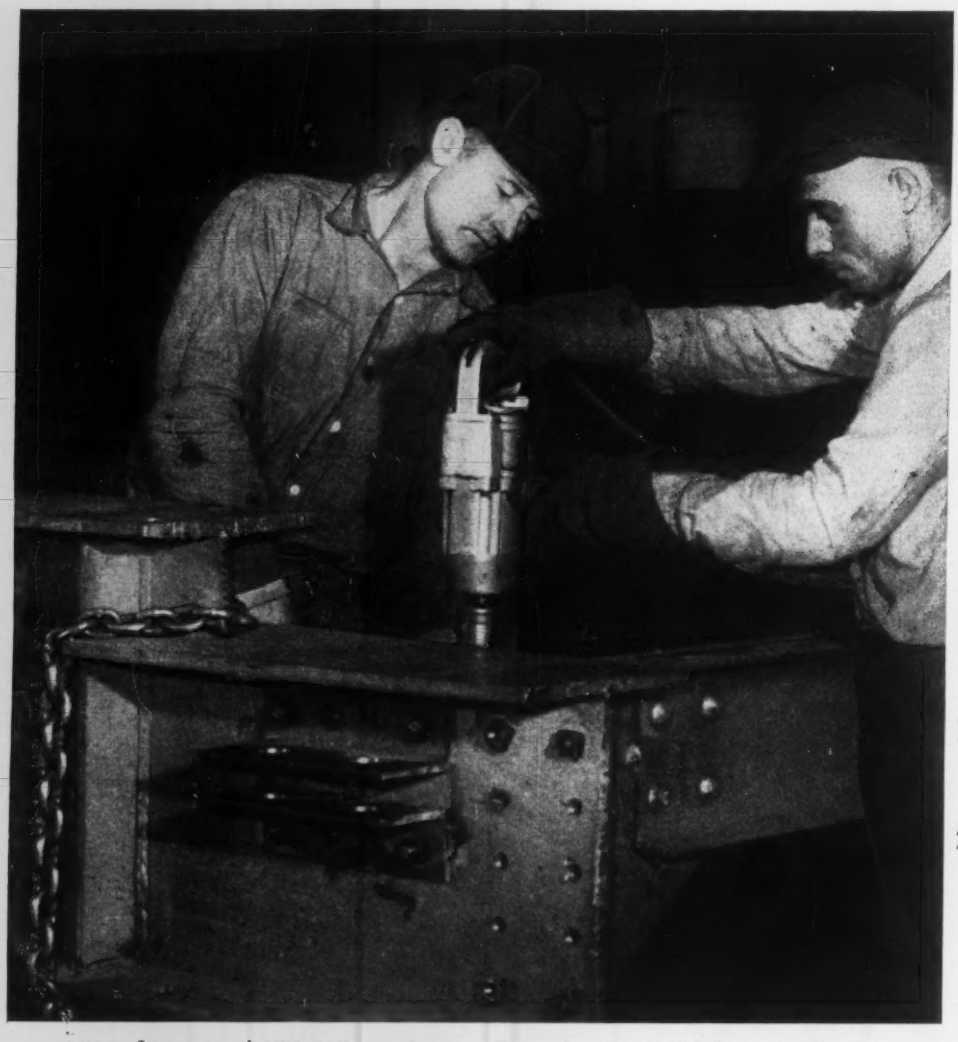
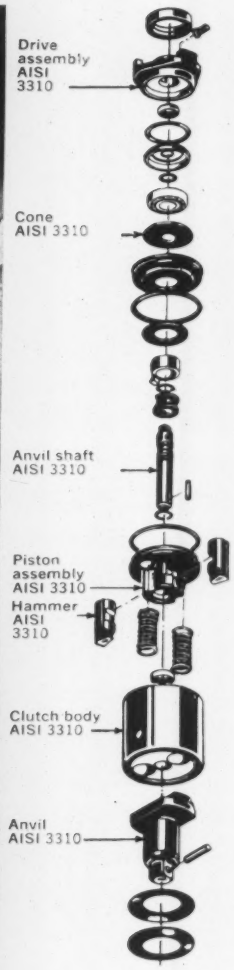


Strong, tough Nickel alloy steel parts stand up to severe shock as Gardner-Denver impact wrench brings nut-and-bolt assembly up tight as a weld.



Exploded view of Gardner-Denver Model 18B-9 impact wrench reveals vital parts made from AISI 3310 Nickel steel for impact resistance.

Hard-hitting impact wrench lasts longer, thanks to 3½% Nickel alloy steel parts

Each time the socket slams against the faces of a big square or hex nut, seven vital parts of this Gardner-Denver impact wrench sustain the same sharp, powerful blow they deliver.

For built-in resistance to this repeated wear, shock-loading and torsional stress, engineers at Gardner-Denver specify AISI 3310 alloy steel (3½% Nickel) for *all* seven components that bear the full brunt of this battering:

- Drive assembly
- Cone
- Anvil shaft
- Piston assembly
- Hammer
- Clutch body
- Anvil

All these parts, made from carburized and hardened 3½% Nickel alloy steel, develop a hard, wear-resistant case backed up by a strong, tough core for resistance to countless shocks.

Typical core properties developed by heat-treated AISI 3310 steel:

Tensile strength	170,000 psi
Yield point, min.	140,000 psi
Elongation	15% in 2"
Reduction in area	60%
Brinell hardness	360

When you design, order, or use heavily stressed machine components, remember that Nickel alloy steels take the tough jobs in stride. For engineering data to help you select the best materials for specific applications, just write. We'll be glad to help.

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IMPACT!

This is a "warhead". It's the front end of a carrier which darts through a pneumatic tube system at speeds up to 20 mph, and is subject to frequent shocks and impact. There's a story behind the choice of LEXAN® polycarbonate resin for this new design . . .

Formerly, destinations were set by contacts along the entire body of the carrier. Engineers of Airmatic Systems Corporation, Saddle Brook, New Jersey, reasoned that if all the control elements could be fitted into a small impact- and wear-resistant head, the rest of the carrier could be designed for easy maintenance and quick replacement. Many plastics had the required dielectric strength, but none could measure up to LEXAN resin's combination of good electrical properties, excellent dimensional stability and extremely high impact strength. LEXAN resin actually withstands over 12 foot-pounds per inch of notch — an impact strength attained by no other plastic!

The new warhead is injection-molded of black LEXAN resin by Berkeley Engineering & Manufacturing Co., Berkeley Heights, N. J. Now when wear and tear take their toll, the transparent carrier body is easily replaced, since it has no control elements. Also, body length can be varied to suit customer needs, and carrier weight is reduced. Printed circuits and compactly arranged brushes and control plates are used. The new design is more attractive, more practical, less costly. And—LEXAN resin warheads have proved in field tests to last longer than the old control units.

G.E. LEXAN polycarbonate resin has raised the quality of many designs to new levels. It has been reduced in price approximately 40% over the past year! Can this tough, new thermoplastic help you? Send for design literature.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

Chemical Materials Dept., Section M-11, Pittsfield, Mass.

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Joe Foster, President, discusses bulk handling's value to Foster Grant customers.

"Here's why a leading molder now buys Fosta® Tuf-Flex in bulk," says Joe Foster

The reason—impressive over-all cost savings.

Sperzel Company, a major manufacturer of plastic containers and plumbing fixtures, saves 1¼ cents per pound by bulk purchases of our polystyrene. Fosta® Tuf-Flex is delivered in sealed "Dri-Flo" cars instead of in the customary 50-pound bags.

Also, Sperzel's bulk-handling system—engineered by Foster Grant and patterned after the one we developed for our *own* operations—saves them another two to three cents per pound in handling costs. The Fosta® Tuf-Flex is blown by special cyclones from the cars into six 150,000-pound-capacity outdoor storage silos—which free some 40,000 square feet of in-plant space. From there, it's pumped into the molding and extruding machines.

The system is expected to pay for itself in less than 18 months. Other advantages: friction in the pipes keeps the resin dry; increased capacity has opened new markets for the Sperzel Company.

If *you* use at least 200,000 pounds of resin a month, you should be considering bulk handling now. And when you start evaluating bulk handling, take advantage of our experience. We'll be glad to counsel with you, and even demonstrate how you can profit from a temporary set-up while your permanent system is being installed.

Call us today, at KEystone 4-6511. Or write Foster Grant Company, Inc., Leominster, Mass.

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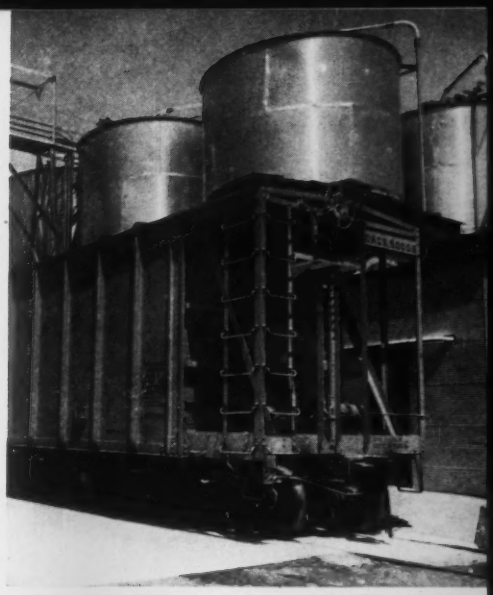
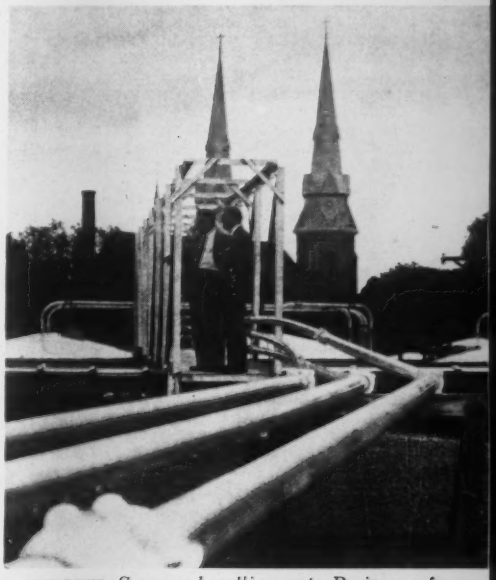
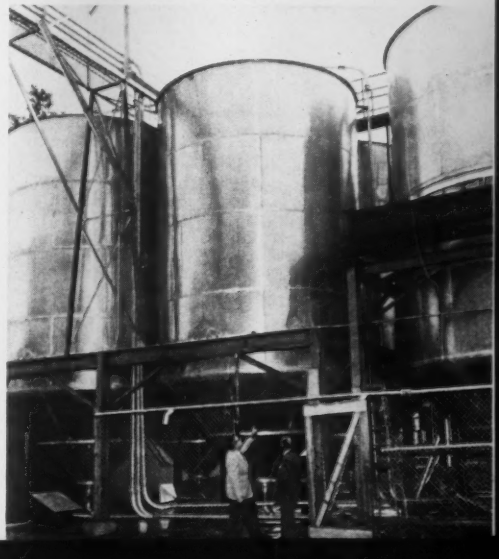


ABOVE: *Saves on resin cost.* Tuf-Flex in bulk costs 1¼ cents less a pound than in multiwall bags.



ABOVE: *Saves on handling costs.* Resin goes from cars to silos to molding machines—automatically.
BELOW: *Saves plant space.* Outdoor storage silos free valuable indoor areas.

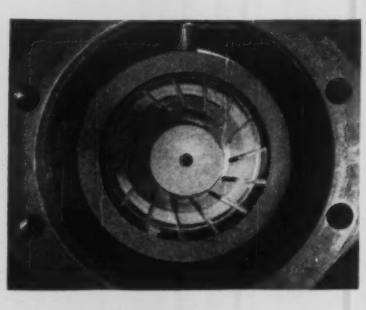


frenchtown engineered ceramics NEWS MEMO

FRENCHTOWN PORCELAIN COMPANY • FRENCHTOWN, NEW JERSEY

Frenchtown rebuilds hydraulic pump with own material

Isostatic forming of alumina ceramics requires intermittent application of medium and high pressures in a pump's hydraulic chamber. This severe service condition often leads to pump trouble. And at Frenchtown, it was no exception. Running at 1200 rpm, vane type rotary pumps delivered 12 gallons per minute at 400 psi. The chatter of vanes under extreme operating conditions resulted in self-destruction with an average service life of less than 700 hours between failures. Standard practice was to return the pump to the manufacturer for renovation. Taking full advantage of the extreme hardness, ability to take diamond polish and great mechanical strength of high alumina ceramics, Frenchtown replaced the steel liner rings with Almanox® 4462. The first unit thus rebuilt has been operating 80 hours a week for over two years, at a speed of 1800



rpm, and at an output of 18 gpm without any perceptible wear. As a matter of fact, the diamond grinding marks are still visible, and the vanes have become burnished to a high finish and hardness. The cost of rebuilding each pump is less than one-third of the unit exchange price.

Why not investigate how Frenchtown engineered ceramics can make your product better? A blueprint or sketch with specifications will bring complete information.

Frenchtown 787 Beryllium Oxide Body offers unique engineering material

Combining excellent electrical properties with high thermal conductivity, Frenchtown 787 beryllium oxide material is available in molded and extruded shapes.

Frenchtown's Molcote® metallized coating may be applied to selected areas for subsequent assembly with metal parts through brazing or high-temperature soldering. Nickel, copper, gold and other plated metals are applied over the Molcote® as specified.

Demand for Frenchtown 787 beryllium oxide as semi-conductor packages indicates a widespread acceptance of this material for use where heat-sink function is coupled to that of electrical insulator. Nuclear instruments and control apparatus also make extensive use of the material's unique properties.

Write for your personal copy of the property chart shown below, as well as details on other Frenchtown engineered ceramics. No obligation.

PROPERTY	UNIT	VALUE
Physical		
Type of body		90% Beryllium Oxide
Color		White
True Specific Gravity		2.95
Bulk Specific Gravity		2.81
Weight	Lb./cu. in.	.106
Pore Volume	Percent	4.74
Water Absorption	Percent	None
Thermal		
Maximum Use Temperature	Degrees F	2750
	Degrees C	1510
Linear Coefficient of Expansion x 10^{-6}	25-100 C	3.45
	25-400 C	6.62
	25-700 C	7.78
Thermal Conductivity Cal/sec/cm²/cm/C	at 100 C	.323
Mechanical		
Compressive Strength	Lb./sq. in.	200,000
Flexural Strength	Lb./sq. in.	27,000
Resistance to Impact (Charpy)	In. lb.	5.5
Hardness (Mohs Scale)		8
(Rockwell 45N)		50
Electrical		
Dielectric Strength	Volts/mil	220
Dielectric Constant at 1 mc		6.36
Power Factor at 1 mc		.00042
Loss Factor at 1 mc		.0026
Te Value	Degrees F	2220
	Degrees C	1215
Volume Resistivity at 200 C	Megohms per Centimeter Cube	
300 C		
400 C		
500 C		370.0
600 C		160.0
700 C		80.0
800 C		38.0
900 C		12.7
1000 C		4.3
1100 C		1.1

For more information, turn to Reader Service card, circle No. 327

Titeflex, Inc., Meets Aircraft Fuel, Lubrication and Hydraulic Line Specifications with

HANDY & HARMAN BRAZE 541

Titeflex operator brazes assembly with torch and hand-fed Handy & Harman Alloy BRAZE 541. *Titeflex is unique in that it makes flexible hose assemblies from raw material to end product—"From End to End, Inside and Out, made* ***RIGHT*** *In Our Own Plant."*

This Springfield, Massachusetts, manufacturer of aircraft and missile fuel, lubrication and hydraulic lines finds that silver alloy brazing with Handy & Harman BRAZE 541 meets rigid operating requirements "all the way down the line."

The tubing and fittings of many of the wide range of assemblies made by Titeflex are 321, 316 and 347 stainless steel and Monel. Brazing is a hand torch, wire and HANDY FLUX operation.

BRAZE 541 is a plastic alloy which melts at 1325° F and flows at 1575° F. Its strength—in shear—at elevated temperatures is 21,500 psi at 500° F and 15,000 psi at 750° F. This alloy's ductility in resisting stress and vibration is very high and its resistance to oxidation and corrosion is equally impressive. The composition of BRAZE 541 is 54% silver, 40% copper, 5% zinc and 1% nickel. It meets AMS Specification 4772.

Aircraft and missile component manufacturers and fabricators are finding—to their and their products' benefit—that Handy & Harman silver alloy brazing is the full and *final* solution to their metal-joining problems. BRAZE 541 is but one of a large family of Handy & Harman alloys, for both low and high temperature applications. We would like to more fully acquaint you with BRAZE 541 and with the advantages that come naturally to silver brazing as a metal-joining (both ferrous and nonferrous) method. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits . . . includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

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IF IT MUST SLIDE ROLL STRIKE SEAL ...OR DEFY HEAVY LOADS AND ABRASION FROM −80° F. TO +250° F. ... MAKE IT WITH

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PROPERTIES OF CURED ADIPRENE POLYMERS				
*Hardness, Shore A	88	95	97	99+
Hardness, Shore D	43	50	60	78
Modulus, 300%, psi	2100	3200	7000	—
**Tensile Strength at Break, psi	7000	8825	8500	8500
Elongation at Break, %	450	480	340	250
Izod Impact Notched ft.-lbs./in.	Flexed	Flexed	20	1.2
Split Tear, ASTM-D 470 lbs./linear inch	50	155	160	200
***Compression/Deflection, psi @ 5% defl.	575	750	1800	6000
Rebound Resilience, %	45	40	42	45
Oil Resistance	Excellent	Excellent	Excellent	Excellent
Low Temperature Brittle Point, °F.	Lower than −80	Lower than −80	Lower than −80	Lower than −80

*Softer compounds ranging from 10 Shore A are also available. **Samples pulled @ 1 in./minute (elastomer stocks normally pulled @ 20 in./min.) ***Shape Factor − 1.0

For more information write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MDE-1, Wilmington 98, Delaware.

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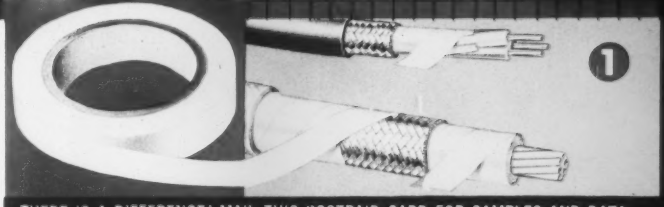
TAPES of TEFLON* by CHEMO



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This is a "must" for present or future project planning—mail the post-paid card at once. You'll receive samples and data on Chemo Insulation Tapes of Teflon plus the catalog of other products of Teflon produced by Chemo. There is a difference.

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Data on:
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- ☐ Molded Sheets, Rods, Tubing
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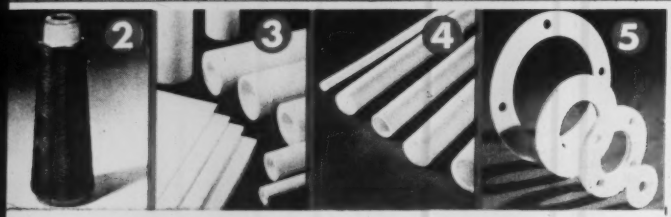

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2 coated glass yarns

Where high temperature insulation and chemical resistance are imperative, Chemo's Teflon Coated Glass Yarns are ideal. Available in a variety of colors, in single or mutiple wound put-ups, in diameters from .0034 up.

3 molded sheets, rods, tubing

Supplied in virtually any form, to meet nearly any specification, molded shapes are free sintered in process; sheets dimensionally stable in every respect.

4 extruded rods and tubing

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5 fluopak® gaskets and gasket envelopes

Engineered for use where accuracy and reliability are of utmost importance...available from stock in smallest to largest sizes.

CHEMO PRODUCTS INC. West Warwick, Rhode Island

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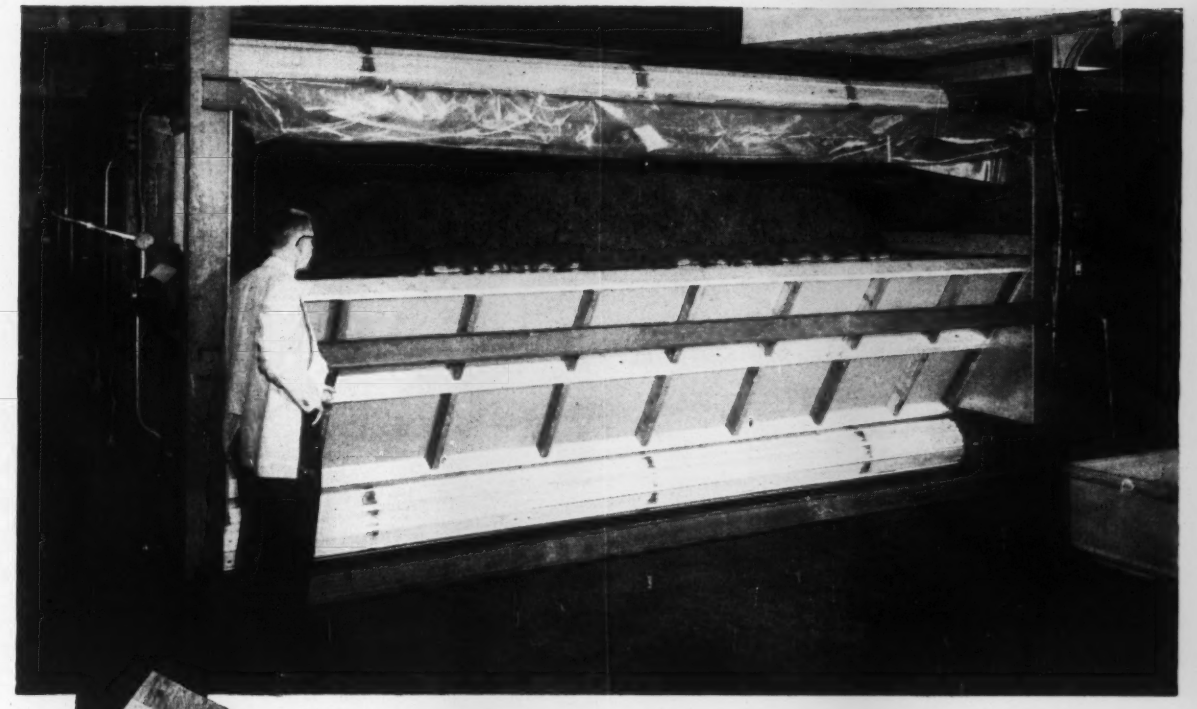

from factory floors...to tobacco conveyors...

GAMBLE solves problems with WOOD!

PROBLEM: Ordinary industrial wood block flooring was breaking up rapidly at heavy-traffic spots like loading docks, intersections, and aisles.

SOLUTION: Wood engineers at Gamble Brothers developed a laminated end-grain hickory block which lasts up to 10 times longer, despite punishing loads that quickly break up ordinary flooring.

PROBLEM: Tobacco conveyors required long orifice-forming slats whose dimensions would not change, even after use in a moisture-control operation in cigarette-making.

SOLUTION: Gamble Brothers designed a laminated slat of maximum dimensional stability, bonded by water-proof, heat-proof, non-taste-imparting adhesives. Our facilities enabled us to build the slats under environmental conditions identical to those to be experienced at end use.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

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the LEAD newsletter

Vol. 2 No. 5

Improved Sound Barriers Employing Lead

Whether you are concerned with a noisy office or a noisy machine, it is important to distinguish between materials that *stop* sound transmission and those which simply reduce sound reflection. A room finished in acoustic tile, for example, seems less noisy because sounds originating in it are not reflected back to a listener in the room. However, a noisy conversation or machinery noises will penetrate the acoustical tile and will leak out to adjoining rooms. To block this leakage, a sound barrier must have two key properties:

weight – the greater the weight (per sq. ft.) the greater the isolation or transmission loss.

limpness – A "limp" partition has a higher sound transmission loss than a stiff one of the same weight.

Lead approaches the ideal in the search for a heavy, limp material. Having a density two or three times that of common building materials (and 10 to 15 times that of wood), it is a "limp" material in the acoustical sense. This combination of properties makes lead desirable as a sound attenuator.

Comparative Weight Advantages

Because of the weight-limpness combination, a little lead will do the same job as a greater weight of other materials. This weight advantage can be of significance to the engineer. For example, while a cinder-block partition weighs 22 lb./sq. ft., 5½ lb./sq. ft. of lead will accomplish the same sound isolation task–with a resultant saving of 16½ lb. for every sq. ft. of partition, or 165 lb. for every linear foot if the ceiling height is 10 ft. This saving can mean lighter slabs and beams.

Cost Savings With Lead Partitions

Studies indicate many materials require 30 times the thickness of lead to accomplish equal sound inhibition. Thickness ratios are even more striking when lead is compared to a stiff, light material like wood. As an acoustical enclosure for machinery, 0.008 inch of lead is as effective as ¾ inch of fir plywood. By replacing a brick wall with ¼ in. lead sheets (allowing a 2 in. thickness for structural framing system for lead) useful floor space conserved, based on a cost of approximately $15 per sq. ft., represents a savings of about $7.50 per linear foot of partition.

Lead "Wallpaper"

If the weight of a wall can be increased without significantly increasing its stiffness, many existing problems of noise transmission can be remedied. With the addition of a layer of lead, as thin as ⅛ in. on each side, the weight of many typical partitions can be doubled, greatly raising acoustical isolation. Lead cloth, similar to leaded vinyls already in production, may be applied in a wallpaper-like fashion.

Lead improves the isolation properties of doors. Approximately 1/16 in. thick lead sheets with a decorated wood veneer laminated to one face of the sheet, and a pressure adhesive laminated to the opposite face, can easily be added to one or both faces of doors where high acoustic isolation is desired.

Machinery Enclosures

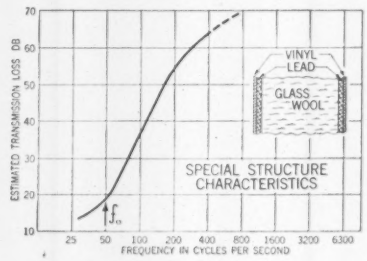
A leaded fabric and pressure sensitive adhesive, or lead foil with pressure sensitive adhesive, has application both in the fabrication of new machinery enclosures and in improving the acoustical properties of existing enclosures. It increases the weight of the enclosure and thus enhances sound transmission loss. And it provides a degree of vibration damping for the enclosure. Finally, because it will lap over joints in the enclosure, it seals airtight. A similar application is suggested for oil-cooled transformers in electrical substations within buildings. Pressure-sensitive lead tape applications might be found in the field of plastic phonograph and radio enclosures, as well as in commercial metal loud-speaker enclosures for installation in the ceilings of buildings.

Lead Backed Acoustic Tile

One of the major problems now facing manufacturers of acoustical tile is that the low weight and porosity of most effective sound absorbing materials permit the transmission of sound. The application of a very thin lead foil to the back of standard acoustical tile will prove effective as a sound damper and should permit the tile manufacturer to produce all of his various decorative patterned tiles without serious modifications.

Special Lead Structures

As an example of a structure of this type, consider the following theoretical five-layer lamination: vinyl film, ⅛" lead sheet, 3" of relatively low density Fiberglass or other resilient board, ⅛" lead and a final coat of vinyl. If the very high transmission losses, particularly at low frequencies, which are indicated by theory are realized in practice, a panel of this construction will have wide application in special areas such as jet engine test-cells, dynamometer cells, special audio-metric facilities and other types of research laboratories.



Versatile Material

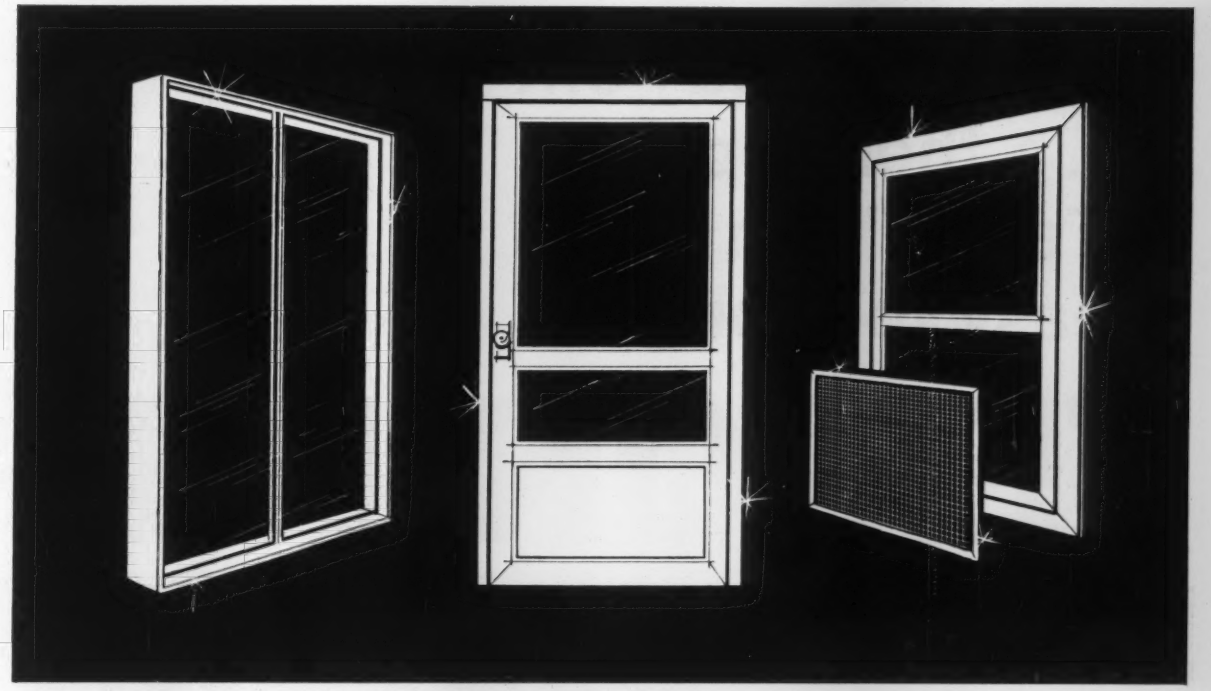
Aside from its economical value as a reclaimer of expensive usable floor space (because of its thinness), lead has other notable advantages. It is tackable–it can be nailed, stapled and be cemented in place. It is paintable–lead sheet as supplied is ready for painting without any further surface preparation and it forms a durable bond with all conventional paints. It is fireproof. It is malleable–it folds or bends over any regular surface. It can be "dressed" over complex surfaces, and is easily cut and worked.

Informative Research Report Available

For more detailed information, a copy of *Improved Sound Barriers Employing Lead*, a report on the research study conducted by Bolt, Beranek and Newman, can be obtained by writing to: Lead Industries Association, 292 Madison Avenue, New York 17, N.Y. 2632

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service card, circle No. 331



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BONDERITE 725 adds exceptional corrosion resistance to aluminum without changing the appearance of the metal!

This new Bonderite produces a *colorless*, amorphous oxide coating on aluminum without the use of electric current. In addition to imparting excellent corrosion resistance to aluminum, Bonderite 725 coatings are an excellent base for clear lacquer and paint finishes.

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Aluminum articles coated in Bonderite 725 and finished with clear lacquer easily meet the stringent requirements of the lime and mortar test specified for certain building products. In addition, articles finished in clear lacquer have good abrasion resistance that reduces scratches during handling and erection.

Bonderite 725 is an efficient, economical chemical treatment applied by spray or immersion application in simple processing equipment. Processing times are as low as 5 seconds.

Up-grade the quality of your products by supplying corrosion resisting Bonderized aluminum in its pleasing natural color. You can add this sales advantage to your product at a treatment cost that will please you.

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New from Du Pont ...a thermoplastic "Teflon" film that's easy to fabricate

TEFLON® FEP

New "Teflon"* FEP-fluorocarbon film has nearly *all* the unique advantages of "Teflon" TFE with one big plus. It's a true thermoplastic that can be easily formed and sealed. And, in many cases, it can be laminated and heat-bonded *without* adhesives. (A cementable type of "Teflon" FEP film is available for your special needs.) Here are just some of the advantages of "Teflon" you get in this new film: • Unique antistick and low-friction properties • Chemically inert to practically all known chemicals • Electricals are high (up to 4,000 volts/mil. dielectric strength) and *stay* high • Performance stays high from -250°C. to over 200°C.

"Teflon" FEP film opens the door to whole new areas of design and product improvement. In fact, Du Pont Film Department technicians, pioneers in industrial film development, are constantly discovering dramatic new possibilities for this unique film. Is there one for your product? Mail coupon and start investigating "Teflon" FEP film. (Briefly describe end use you have in mind.)

**Du Pont trademark*

FILM

FORM IT!

TYPICAL PHYSICAL PROPERTIES

Melting Range	545-563°F.
	285-295°C.
Ultimate Strength	3,000 psi.
Ultimate Elongation	300%
Tensile Modulus	43,000 psi.
Flex Life	4,000 cycles
Coefficient of Friction	0.09

ELECTRICAL PROPERTIES

Dielectric Constant	
23°C., 100 cps. to 100 Mc.	2.1±0.1
1000 cps., -40°C. to 225°C.	2.13-2.04
Dissipation Factor	
23°C. 100 cps. to 100 Mc.	.0002—.0007
1000 cps., -40°C. to 240°C.	.0002
100,000 cps., <-40°C. to 240°C.	.0005
Volume Resistivity	
-40°C. to 240°C.	$>10^{17}$ ohm/cm
Surface Resistivity	
-40°C. to 240°C.	$>10^{16}$ ohm/sq. unit
Dielectric Strength	
23°C., 60 cps.	
1 mil film	4000 volts/mil
15 mil film	1700 volts/mil
Surface Arc Resistance (sample melted in arc . . . did not track)	>165 sec.

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Weirkote, the modern continuous-process galvanized steel, is now being produced at our new Midwest Steel facilities in the Chicago area, as well as at our Weirton Steel division in the Pittsburgh area.

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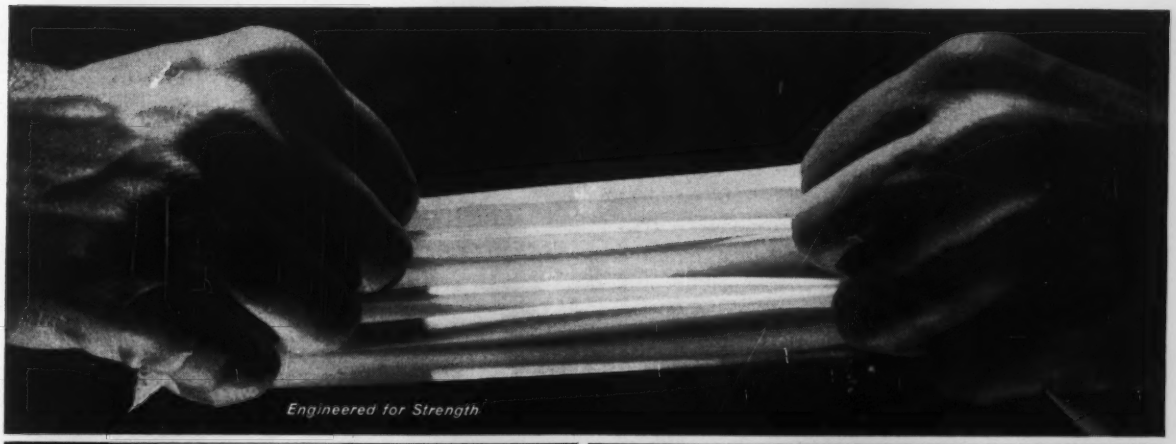
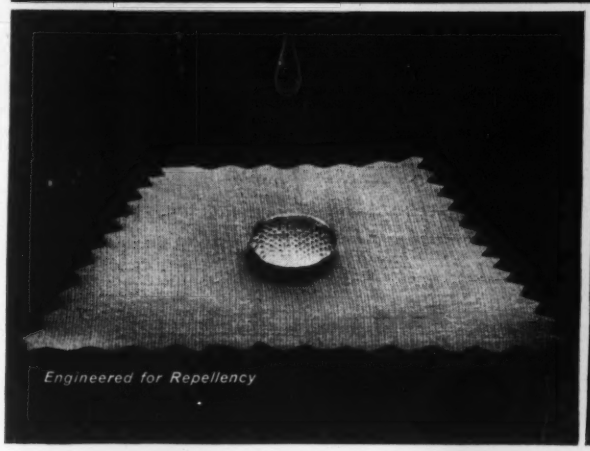
Born to live a short life,
this missile guidance component must perform as if it had to last forever! CDF molded this part under high pressure from glass fabric epoxy laminate to meet rigid military electro/mechanical requirements.
Result: a panel with excellent electrical insulating properties and high mechanical strength that provides significant savings in space and weight, helps minimize vibration.

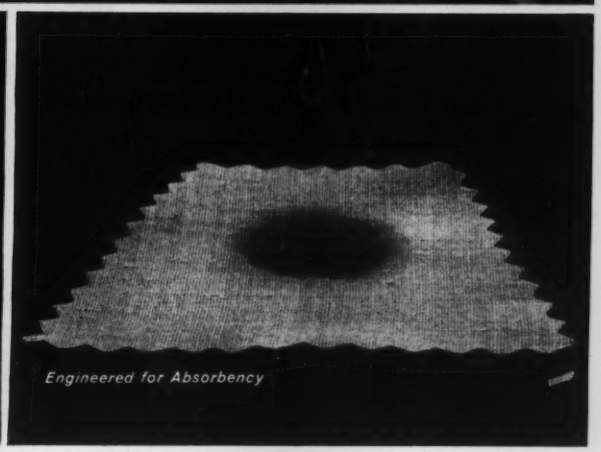
CDF **CONTINENTAL-DIAMOND FIBRE**

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Budd COMPANY

An example of Avisco Rayons in Industry







There's an application for Avisco® rayon in your business

The big news in industry today is the increasing use of Avisco rayon fibers. Versatility is the reason. Avisco rayon can be custom engineered to meet your end-use requirements.

Need strength? Avisco rayon fibers add backbone, tensile and flex life to beltings, burst strength to hoses, tensile and tear strength to coated fabrics and laminated paper, film and foil.

Need absorbency (or repellency)? Avisco rayon fibers are used extensively in medical and hygienic products.

Need superior filtration? Avisco rayon fibers are produced in a wide range of precise micron diameters to control porosity and improve efficiency.

Whatever you make, there's a way you can save time and money with Avisco rayon fibers engineered to your specific requirements. Find out now.

QUICK REPLY COUPON 6-4

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American Viscose Corporation
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Company_____

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AVISCO AVISCO **RAYON**

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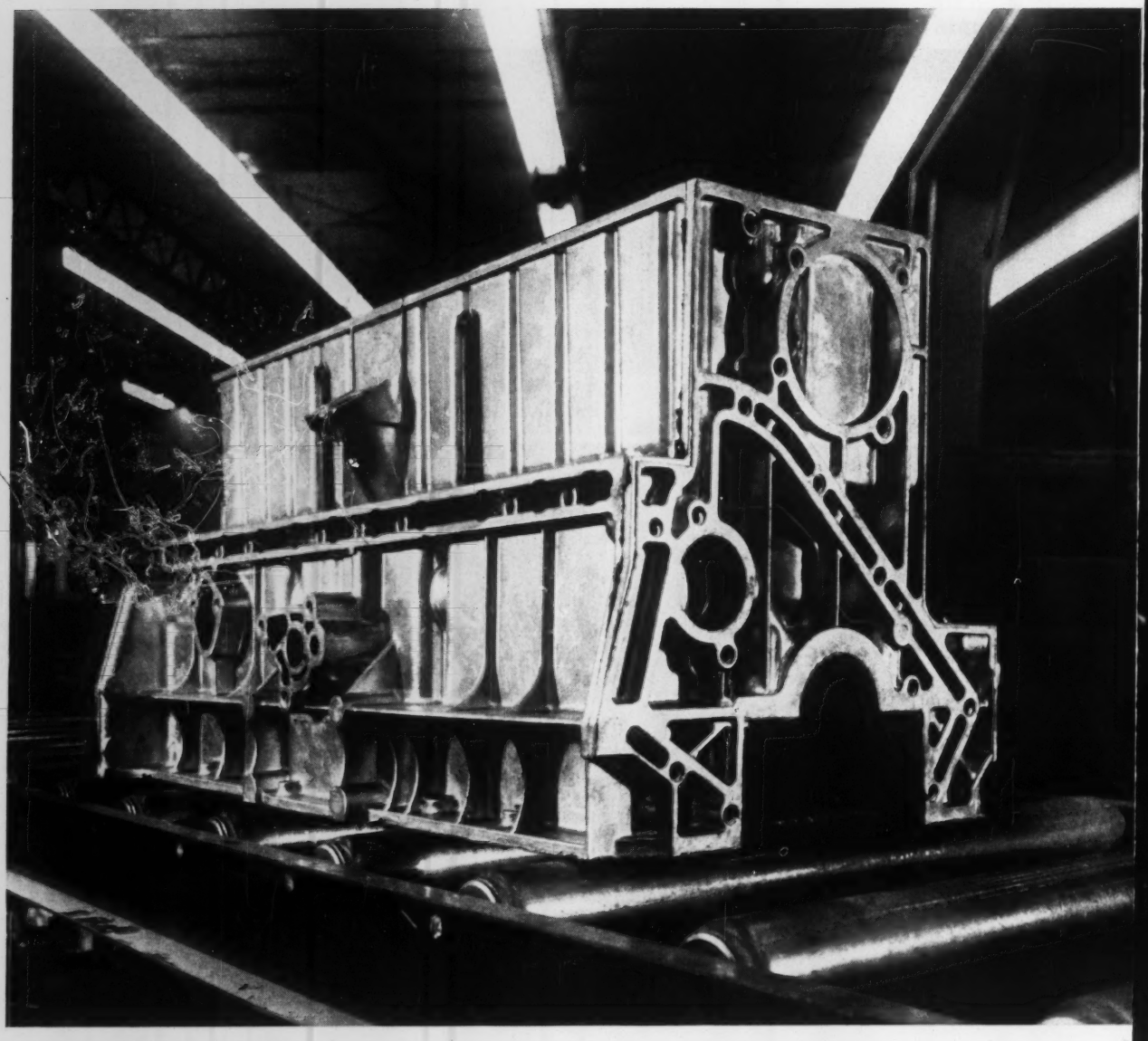


World's first die-cast aluminum "six"

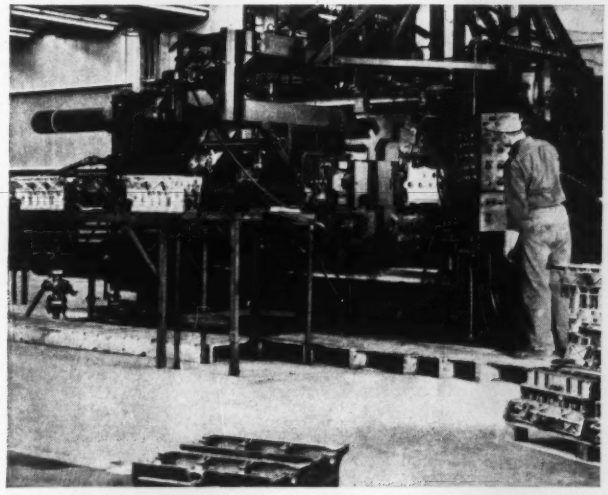
Saves 80 pounds for American Motors' new Rambler Classic . . . incorporates specially bonded cast iron liners in dry sleeve design.

This engine block is the biggest die casting ever mass produced. It's the world's first six-cylinder block for passenger car use to be die cast in aluminum.

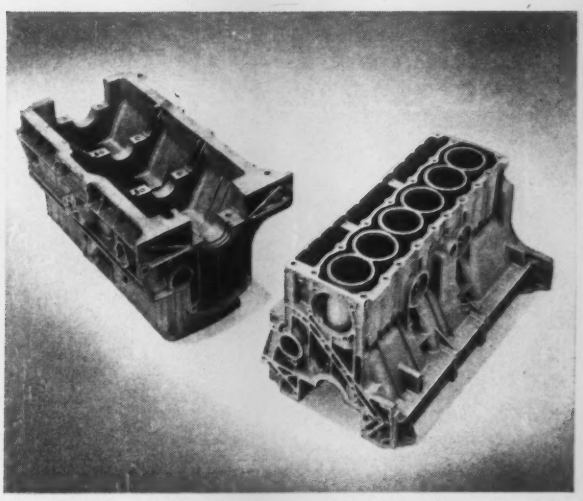
It's a 67 pound lightweight including 14 pounds of centrifugally cast iron cylinder liners. That means a total saving of 80 pounds deadweight . . . now standard in the new Rambler customs, optional in other Rambler models.

Light but strong. Aluminum's excellent physical properties are fully utilized by careful die cast design and photostress analysis. Outstanding strength, soundness and precision provide a big plus for heavily-emphasized Rambler quality.

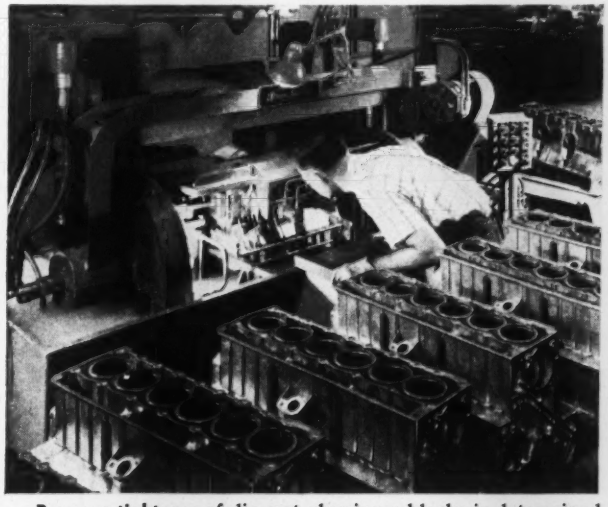
BMI bonding is simple and sure. The BMI—or Bi-Metallic Interlock developed by Doehler-Jarvis—mechanically "anchors" the liners by means of their specially prepared cast surfaces. Since these liners are centrifugal castings, no knurling, crimping or splining is needed. An intimate locking action occurs as the molten aluminum is injected into the die . . . under 8,000 psi. The result: an inseparable bond with excellent heat-transfer properties.



A block every three minutes . . . from 2,000 ton machines like this. In three tenths of a second, machine injects a 70-pound "shot" of molten aluminum . . . under 8,000 psi.



Centrifugally cast iron liners—up to 260 Brinell—are cast in place with specially prepared surfaces which lock inseparably with molten metal under pressure.



Pressure tightness of die-cast aluminum blocks is determined by testing on a machine specifically designed for this purpose. Advanced quality control helps protect highest standards.

Palletized for rapid delivery, these finished blocks can reach American Motors assembly plants by rail . . . or in trucks of the Doehler-Jarvis fleet.

rolls off the line at Doehler-Jarvis

To design for efficient production, American Motors and Doehler-Jarvis engineers combined specialized know-how with liberal imagination. An oil gallery for hydraulic valve lifters is an integral part of the block casting. Liner inserts and loose pieces for casting undercuts are placed by automatic attachments that never slow down the casting cycle.

To make new ideas pay off, perhaps you can use the facilities, resources and practical experience offered by Doehler-Jarvis. Eight plants provide the capacity—and the flexibility—to serve large companies well, and to help small ones grow. For detailed information, simply phone or write the nearest Doehler-Jarvis plant or office.

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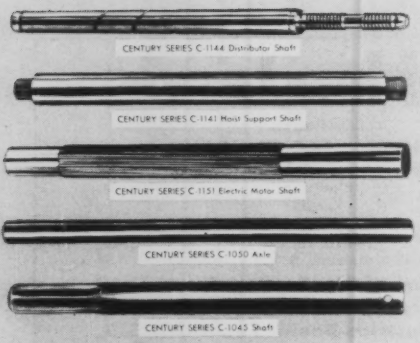
Brunswick CORPORATION puts "Mechanical Brain" to work


CENTURY SERIES C-1144 Distributor Shaft
CENTURY SERIES C-1141 Hoist Support Shaft
CENTURY SERIES C-1151 Electric Motor Shaft
CENTURY SERIES C-1050 Axle
CENTURY SERIES C-1045 Shaft

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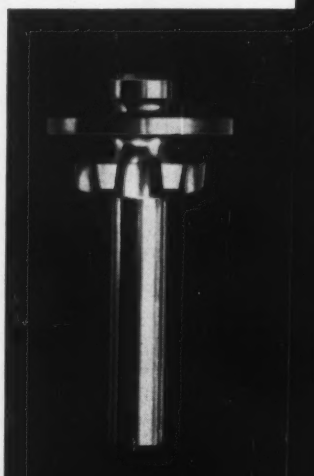


with ELECTRUNITE Mechanical Tubing

Better bowling by Brunswick. Better automatic pinsetting with ELECTRUNITE. That's the story behind today's most popular participation sport—bowling for the entire family.

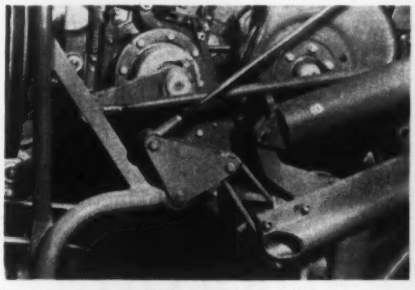
The Automatic Pinsetter, designed and produced by the Brunswick Corporation, Bowling Division, Chicago, Illinois, is a precision engineered, rugged, mechanical unit designed to set pins, sweep away "deadwood" and reset remaining pins, all in the matter of seconds, automatically.

Republic ELECTRUNITE Mechanical Tubing was specified because it met the extreme tolerance requirements with a substantial savings in weight. No sacrifice in strength. High quality ELECTRUNITE is delivered ready for fabricating. Excess manufacturing costs squeezed out.

Republic, world's largest producer of specialty welded tubing, offers ELECTRUNITE in a wide range of sizes, gages, and wall thicknesses, supported by technical and metallurgical assistance. Prompt price and delivery quotations usually within twenty-four hours. Call your Republic representative. Or, write direct. Use coupon below.

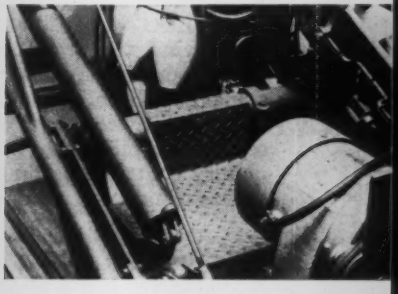
In just 12 seconds, the Brunswick "Magic Brain" sets up the alley for the next shot. The ball takes an elevator ride on ELECTRUNITE Mechanical Tubing to start the return trip to the bowler.

When the ball hits the hinged pit cushion the motion is mechanically transferred to trigger the machine cycle. ELECTRUNITE Mechanical Tubing is used for the pit cushion support arms construction.



ELECTRUNITE Tubing in three key locations assures smooth, trouble-free lifting, sweeping, Automatic Pinsetter operation. ELECTRUNITE is delivered ready for fabricating, saving production time and costs.

ELECTRUNITE was specified by Brunswick because it meets the extreme tolerance requirements, eliminating the need for any additional machining operations.



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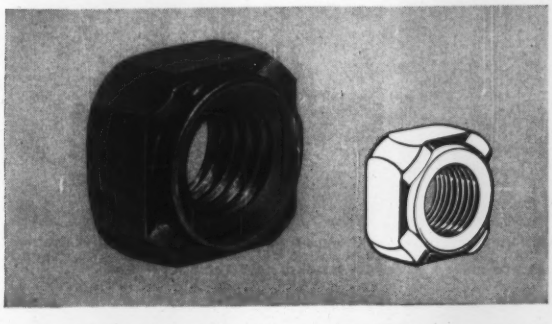

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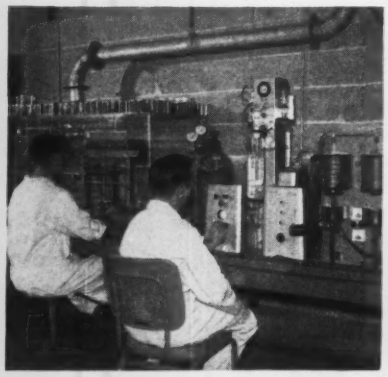
Spectrographic analysis of BERLYCO beryllium is important in controlling quality and assuring proper composition.



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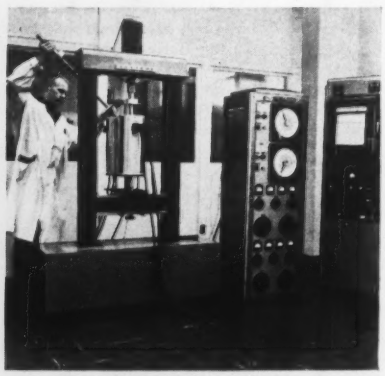

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ENGINEERING & DESIGN

...AT A GLANCE

Inflatable gliders for reentry into the atmosphere can be made from available high-temperature flexible materials, such as plastic-coated wire screen or fibrous glass, according to a recent report. The maximum sustained wing temperature of a typical vehicle would only be 1300 F. Continuing materials development would increase operating temperature, payload and structural efficiency. Such gliders would have the advantages of foldability and low landing speeds.
Source: Technical Note D-538, National Aeronautics and Space Administration, Washington 25, D.C.

'Square butt' welding with high currents (up to 600 amp) is being used to weld heavy-wall aluminum cylinders for nuclear applications. The method is said to be faster (about 8 ipm), more economical, and requires less heat input than conventional methods. Welds are made on square end-to-end joints thus eliminating V-joints.
Source: Linde Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17.

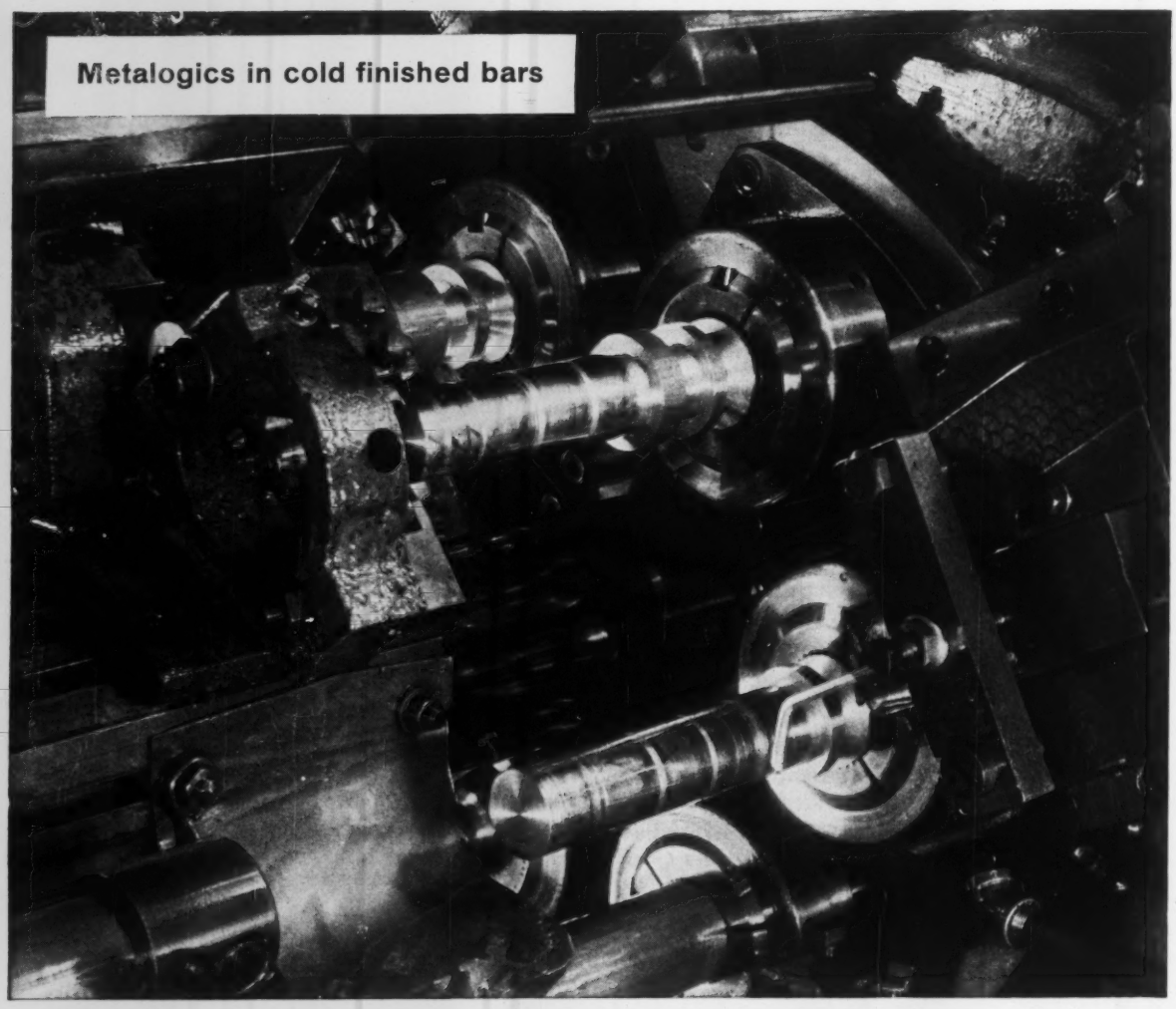
Urethane rubber has outlasted steel in ductwork used to move foundry sand from drying units. The sand, which is blown through the line at relatively high speed and at temperatures up to 175 F, previously cut through two right angle bends in mild steel ducting in about a month. Special abrasion resistant alloy steel wear plates welded to the elbows lasted only two months. Sheets of ⅛-in. thick urethane rubber bolted to the elbows lasted six months.
Source: E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.; plates by Dike-O-Seal, Inc., Chicago.

Thermal expansion and contraction of solid propellants in missiles is being compensated for by phenolic-bonded fibrous glass pads. Contraction during cold weather can crack the propellant and expansion can loosen grains of the propellant from the main block. The molded pads are said to absorb launching shocks and G-loads and to resist environmental deterioration and relatively high temperatures.
Source: Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

Oriented nylon sheeting used as conveyor belt cores is said to increase belt life in extremely rigorous applications 50 to 100%. Orientation increases the tensile strength of the nylon and reduces its residual elongation.
Source: Belts by Goodall Rubber Co., Trenton, N. J.; nylon sheet by Spencer Chemical Co., Kansas City, Mo. and Moldings & Extrusions, Inc., Wauregan, Conn.

Continued interest in liquid metals as power transmissions fluids is evidenced by a recent report stating that the eutectic alloy of sodium and potassium (known as NaK-77) is the only fluid available for use where an extremely wide operating temperature range (10 to 1400 F) and long life are prime factors.
Source: Defense Electronics Div., General Electric Co., Schenectady, N. Y.

Reinforced Teflon o-rings are used to seal glass ports in a remote welding unit for encapsulating radioisotopes. The glass fiber-reinforced o-rings are said to provide a combination vacuum and gas seal against 300 psig pressure during wide temperature variations. The rings also cushion the ports during installation.
Source: Rogers Corp., Rogers, Conn.



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	Advantages	Limitations
Coal Tar Enamel	Low moisture vapor transfer—available in heavy thicknesses	Application conditions must be carefully controlled to get good adhesion
Coal Tar Epoxy	Excellent water resistance up to 180 F—resists many solvents and acids—good long-term adhesion	Limited weather resistance—poor curing below 60 F—black color only
Epoxy	Excellent adhesion—good resistance to water at elevated temperatures—resists abrasion	Slow curing at low temperatures—mediocre resistance to strong acids
Vinyl	Excellent resistance to water and other media. Good combination of mechanical properties	Close control required during application—multiple coats required
Chlorinated Rubber	Good weather resistance and adhesion	Because of thinness is conducive to water vapor transfer
Phenolic Tung Oil	Good water resistance—easily applied—good mechanical properties	Limited resistance to alkalis and weathering—long drying period required
Concrete	Excellent record of long term water immersion	Limited mechanical properties if too thin
Zinc-Lead Silicate	Exceptional weather resistance—excellent mechanical properties	Not as good as some others under constant water immersion—must be applied over perfectly clean substrate

This chart ↑ and the following article → will help you in

Picking a Coating to Resist Water Corrosion

Water is the cause of most corrosion problems. No one construction material or protective coating is ideal for all water exposures . . . each application has its special set of problems. This up-to-date survey tells about:

The different types of water corrosion

How water affects coatings

What water resistant coatings are available

How to select the right one

by C. G. Munger, *Vice President, Research and Manufacturing, Amercoat Corp.*

Type of corrosion influences coating selection

Before we can make an intelligent decision on how to best fight water corrosion it is essential that we understand the destructive reactions that take place:

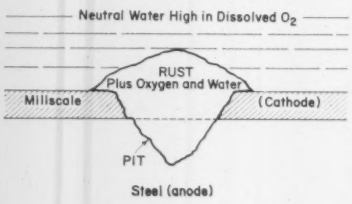
Dissimilar metals cause galvanic corrosion

This is the reaction that occurs when dissimilar metals contact each other. For a good example, consider a brass or bronze valve that is connected into a steel line. The steel area adjacent to the brass becomes badly pitted and corroded.

Electrolytic corrosion is very common

Electrolytic or local anode-cathode type corrosion is probably the most common kind of corrosion and it may take many forms.

If bare steel is exposed to water with average conductivity and oxygen content, its surface will immediately develop areas where the metal goes into solution rapidly (the anode), and other areas where there is no loss in metal (the cathode). This is a common condition in tanks and pipelines. Also, where water has a high oxygen content (as at trash racks, gates, pier plates and similar areas on dams) electrolytic corrosion can produce large anodes:



The huge excess of oxygen will remove all the hydrogen formed, and even a small cathode will be capable of neutralizing the electrons formed where the iron goes into solution. In areas such as this a massive oxygen concentration cell is established.

Tuberculation in cast iron is another manifestation of electrolytic corrosion. Strong anodes and cathodes are set up on the surface, whereupon the iron goes into solution and leaves a pit which retains the graphite crystals from the original iron structure. The tubercle is the iron oxide that forms over the mouth of the pit and it grows as rapidly as the iron goes into solution. This is the process commonly known as "graphitization."

Sulfide water corrosion is rapid

Where sulfides are common in water much corrosion can be traced to the direct reaction of hydrogen sulfide with metal. This reaction is rapid, can proceed as a direct chemical reaction and does not require oxygen or an anode or cathode. However, where oxygen is present the reaction is self-perpetuating because the iron sulfide formed is oxidized to iron oxide which releases the sulfide ion to react again with the ferrous metal.

Pure water corrosion mainly confined to concrete

High purity water rapidly dissolves the calcium out of concrete. This exposes the aggregate and can eventually destroy the structure. The reaction will go on until an equilibrium is reached, at which point there is sufficient calcium in the water to prevent further solution. Fortunately, most concrete and cement will last indefinitely because most water (except that taken directly from snow fields) is sufficently hard or contains enough calcium to prevent any reaction from occurring.

Water affects coatings three ways

The effect of water on steel and concrete is reasonably well known. However, what is the effect of water on the coatings and linings that are used to protect these surfaces? Water affects organic coatings by:

1 Water absorption

This is the amount of water that will accumulate and be held in the intermolecular spaces in an organic material. It is specific for each type of resin and does not have a major effect on coating life since it is a static property.

2 Moisture vapor transfer

This action is much more important than water absorption. It is the action of water vapor in molecular form that passes through the organic coating. Each coating material has its own characteristic rate of transfer and, in general, better protection is provided by coatings with low vapor transfer rates. For example, even though polystyrene resin has a zero water absorption it has a very high rate of moisture vapor transfer. This accounts for the fact that no satisfactory coatings have been made of the material to date.

3 Osmosis

The phenomenon of osmosis has a great effect on coating life. It can be defined as the passage of water through a semipermeable membrane from a solution of low concentration to one of higher concentration. Because all organic coatings transmit moisture, they are semipermeable membranes and as such are definitely subject to osmosis.

Osmosis is particularly damaging to coatings that are applied over unclean steel surfaces containing chlorides, sulfates or other ions. As soon as the water vapor penetrates a coating it forms a concentrated solution at the coating-steel interface. This concentrate then draws additional water, producing blistering and failure.

Seven types of water resistant coatings

1 Hot-applied coal tar enamels have low vapor transfer

Coal tar enamels are probably the oldest and best known water resistant coatings. The thickness of the coatings—1/16 to 3/16 in.—combined with their low moisture vapor transfer, provides an effective water barrier that minimizes underfilm corrosion. The coatings are applied hot without shrinkage-producing solvents (for additional data see "Bituminous Coatings," M/DE, Aug '59, p 100).

Some of the disadvantages of the coatings should be noted. Because adhesion can be critical and inconsistent, application factors such as humidity, temperature, dust, and time between coats must all be carefully controlled. Also, enamel fumes are potentially hazardous, especially in pipe and other enclosed areas.

Hot-applied coal tar enamels are not recommended for weather exposure. They are susceptible to temperature changes: cold weather causes cracking and crazing, and warm weather makes the coatings sag and flow. Although coal tar enamels work well as pipe linings, they are unreliable as above-ground tank linings for this reason.

2 Coal tar epoxy coatings resist hot water

These coatings are made from a mixture of coal tar and epoxy resins plus a hardener or curing agent. The coatings combine the best properties of each resin, including excellent water resistance even at temperatures up to 180 F, and good adhesion to steel and concrete for long periods. The crosslinked structure of the coatings makes them insoluble in most solvents and provides good resistance to acids, alkalis and salts. A thickness of 10 to 15 mils per coat can be obtained.

Principal disadvantages of the coatings are their limited weather resistance, poor curing properties below 60 F, and availability in black color only.

3 Epoxy formulations have good mechanical properties

Almost an infinite number of combinations of basic epoxy resins and curing agents are available (e. g., see "Epoxy Coatings for Metal Products," *Materials & Methods*, Apr '57, p 130). Of the few types that are effective as an air drying coating for water exposure, the combination of epoxy and polyamide resins is especially good. It provides excellent adhesion to concrete and steel and good resistance to continuous water exposure at elevated temperatures. It resists abrasion and chemicals, especially alkalis and salts.

The epoxy-polyamide coating is relatively easy to apply by spray gun over a clean, blasted surface (up to 15 mils can be applied in one coat), and it cures at temperatures above 60 F in a few hours. However, curing is very slow below 60 F, and almost impossible below 40 F. Resistance of the coatings to strong acids is mediocre, although this makes little difference in most water systems.

4 Vinyl coatings have excellent all-around properties

The excellent properties of vinyl coatings are due to the fact that they are made from resins that have been completely reacted prior to being made into coatings. Because the coatings are formed by simple evaporation the resins do not require oxygen, a catalyst or any additive (see "Vinyl Coatings for Metal Products," *Materials & Methods*, Mar '57, p 130).

Although vinyl coatings are relatively thin they form an exceptionally tight and homogeneous film which serves as an effective barrier against water, oxygen and ions. They also have broad chemical resistance and are inert to most acids, alkalis and salts, as well as to oil, grease and alcohols.

They excel in water and moisture vapor resistance and have an absorption rate of only a fraction of 1%. Properly formulated coatings have exceptional weather resistance: tests under Florida conditions have shown no change except mild chalking in many coatings after more than eight years continuous exposure.

Because of their toughness vinyl coatings will withstand much abuse and abrasion. And when properly applied they have excellent adhesion, especially to sandblasted steel. When deliberately scored they show no tendency to chip or shatter and maintain a perfect feather edge over the edge of the base metal.

Because they are thermoplastic, vinyl coatings are flexible and extensible. These properties allow the coatings to expand and contract with the base metal despite rapid and wide changes in temperature.

It is often stated that vinyl coatings peel. One reason is that

Watch Out for Different Types of Water

The problem of water corrosion is complicated by the existence of many different types of water, each of which creates its own set of conditions which must be overcome. For example:

Swamp water that may be pure enough to drink, is ordinarily acidic and will rapidly corrode both steel and concrete.

Sulfide water which is prevalent in many areas of the South, reacts readily with most metals such as iron, steel, brass and copper.

Highly conductive water usually with a high chloride content, leads to rapid formation of anode-cathode areas on steel, resulting in severe pitting. Water with a high oxygen content will also create anode-cathode corrosion cells.

Pure water from snow fields will rapidly dissolve the calcium out of concrete, leaving the aggregate exposed.

their high tensile strength—about 3000 psi—often exceeds their adhesive strength. Thus, it is possible to tear the coatings from a surface. In contrast, oxidizing coatings have low film strength and cannot be peeled in one piece unless there is little or no adhesion.

Almost all of the disadvantages of vinyl are tied in with application conditions. For example:

a. They usually contain strong solvents which may lift and loosen old paint during recoating operations.

b. Because the films are relatively thin, multiple coats are required to build proper thickness.

c. Although vinyl coatings dry rapidly (dust-free in 2 to 5 min) this property can be a disadvantage if, due to improper application, the coating is dry before it hits the surface. This condition, known as overspray, produces a very rough, porous film.

d. Because of their high molecular weight and cohesiveness, vinyls also have poor wetting properties. To obtain proper adhesion they must be applied over a clean surface and a special primer.

5 Chlorinated rubber can be modified for many uses

When natural or synthetic rubber is chlorinated it forms a very hard, thorny resin with none of the properties of rubber. It is soluble in aromatic solvents and forms a hard, tough film which, however, must be modified with a softer resin (usually an alkyd) to improve workability and prolong adhesion.

Modified chlorinated rubber coatings offer good adhesion, especially to concrete, and good resistance to dilute acids and alkalis, depending on the modifying resin. Their weather resistance is good and they are commonly used to line concrete swimming pools.

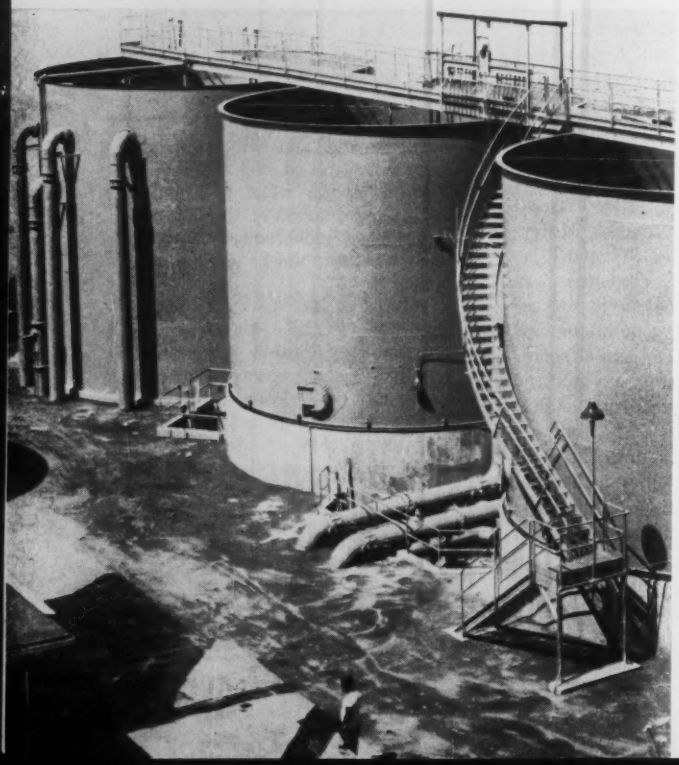
One of the drawbacks of the coatings is the fact that their good properties often depend on how well the modifying alkyd resins are used. Also, the coatings tend to increase in brittleness and lose adhesion with time and with temperature changes. A further disadvantage: because of their relative thinness—4 to 6 mils in three coats—the coatings are conducive to water vapor transfer.

6 Phenolic tung oil coatings have been widely used

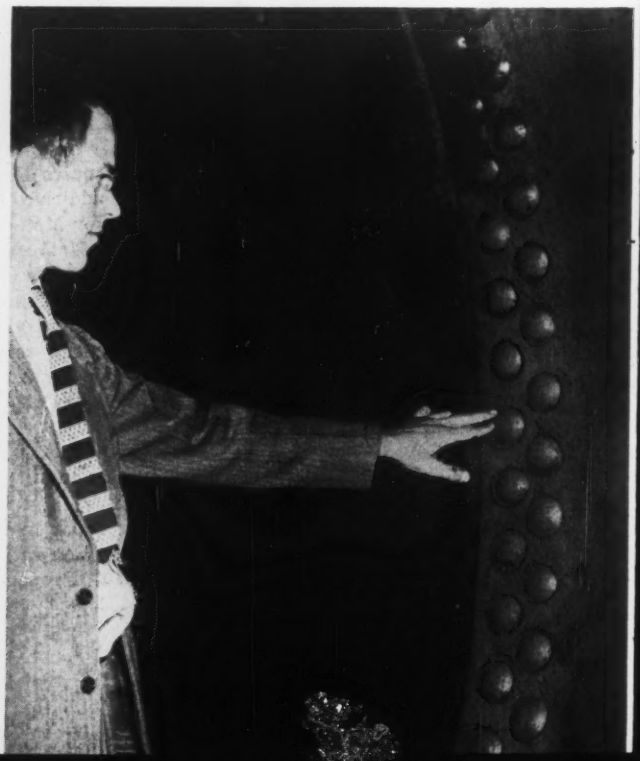
Suitably formulated phenolic tung oil coatings have a very good record for water applications. One important formulation now in use consists of a base of 25-gal tung oil phenolic varnish (i.e., 25 gal of oil per 100 lb of resin) pigmented primarily with red lead and containing small amounts of chromates and inert materials. This formulation is easily applied and forms a hard, tough film with excellent adhesion and resistance to blistering. Three coats form a 10-mil film that has excellent wetting action and high affinity for steel. The coating has good aging characteristics when continuously immersed, and it will retain adhesion even under very cold conditions (see "Phenolic Coatings for Metal Products," *Materials & Methods*, Jan '57, p 106).

Some of the less desirable properties of the coating are its: 1) limited resistance to alkalis—this can be detrimental when anodic-

Above-ground water tanks *are coated inside and out with four-coat vinyl system to resist effects of weathering as well as total water immersion.*



Power generator scroll case *interior surface and rivets protected with vinyl coating show no sign of deterioration after five years service.*



cathodic areas are formed or where cathodic protection is used; 2) limited weather resistance unless specially pigmented; 3) relatively long drying period required to obtain full properties.

7 What about inorganic coatings?

Not too many inorganic coatings can be used to resist water corrosion. However, those coatings that are available provide excellent service.

Concrete linings and coatings on steel and cast iron pipe have been used for many years with great success and few failures. Steel pipe has been fully protected during constant immersion as long as 50 to 100 years.

One of the most successful inorganic coatings is a zinc-lead silicate formulation which has exceptional weather resistance in any climate and which increases in hardness, toughness and adhesion through exposure and aging. The coating becomes very hard and abrasion resistant a few hours after application and adheres permanently. It resists alternate wet and dry exposure even in pure water, and its high zinc content provides a definite measure of cathodic protection to scratches and abraded areas.

This coating, like all others, has some less desirable features. It operates best under alternating wet and dry conditions and, although it has good resistance to water under constant immersion, its resistance is not outstanding. Also, it must be applied over a perfectly clean steel surface because any organic contaminants will prevent good adhesion.

How to select the right coating

Evaluation of the various water resistant coatings shows that no one coating is perfect for all types of applications. Each coating has a different set of properties which make it more suitable for a particular exposure. Thus, end use is the determining selection factor. For example:

Pipe—continuously full

There is little doubt that concrete or hot-applied coal tar linings are the best materials to use on ferrous pipe which is continuously full of water. These two coatings have been giving good service for 50 years or more.

Pipe, penstocks and siphons—above ground

The following discussion applies to coatings for pipe, penstocks, siphons and similar structures which are subject to cyclic water immersion and to varying temperature conditions. Based on tests made at Shasta Dam, the U. S. Bureau of Reclamation's Paint Laboratories have found that the best coatings for such structures are a phenolic resin, red lead paint; a single-solution-type vinyl resin paint; a multi-coat vinyl resin paint; and a cold-applied coal tar paint. Investigators say that these materials perform better than coal tar enamel or a cement mortar lining under conditions where exposed water-bearing pipe (e. g., a siphon) is empty during extremely cold weather. Coal tar enamel is susceptible to cold weather damage: at low temperatures it loses its plasticity, and it may crack and lose its bond in steel pipe below —20 F.

Steel storage tanks —above ground

Steel storage tanks create tough corrosion problems because of extreme temperature changes and wide variations in water exposure. Some areas are continuously exposed, others get alternate exposure, and others are not exposed at all. Under such conditions vinyl coatings have given excellent service for as long as 10 to 15 years. It is hoped that the relatively new coal tar epoxy coatings will also provide good protection.

Dam gates, locks, trash racks, canal gates

These applications are particularly difficult because, in addition to total immersion, coatings must resist weathering, alternate wetting and drying, water spray, ice and abrasion. Experience over many years has shown that the vinyls and zinc-lead silicate coatings are most effective under these conditions.

Deionized water tanks and equipment

The protection of deionized water equipment presents some different problems in that contamination has to be prevented and the water must be kept pure and free from ions. Vinyl coatings have a long, trouble-free background for this application, and equipment coated in the early part of World War II is still giving good service. Considering their properties, it appears that good service should be provided by the coal tar epoxy coatings on steel and the more conventional epoxy coatings on concrete.

Atomic energy equipment

One of the corrosion problems with atomic energy equipment is the pure water which is used as a shield for atomic radiation. Although concrete is the primary surface, pipe and other metal equipment may also be exposed to the pure water. A protective coating for such surfaces must not only resist water and prevent its contamination by ionic material, but must also resist high density radiation, have excellent adhesion to concrete, resist some abrasion, be capable of decontamination, and be colored white for visibility.

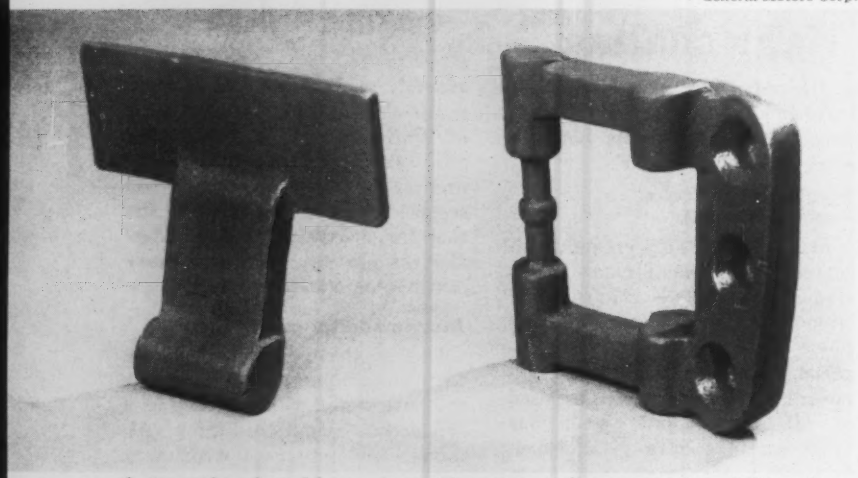
The coatings with the oldest satisfactory record under these difficult conditions are the vinyls. They have been giving excellent service since 1944 in reactor and uranium storage basins. In more recent years the epoxy coatings have also worked out successfully because of their excellent adhesion to concrete, appreciable thickness, and good radiation resistance (see "Epoxy Coating Resists High Gamma Radiation," M/DE, Feb '60, p 9).

Where to Use Shell Mold Castings

They can . . . reduce weight
eliminate machining
give surface uniformity
eliminate welded assemblies

by the Editors, *Materials in Design Engineering*

General Motors Corp.



Automotive door hinges *cannot be economically converted to shell castings.*

COMPARISON OF THREE PROCESSES

Process →	Green Sand	Shell	Investment
Casting Weight	1 oz to several tons	**1 oz to several hundred pounds; usually under 25 lb**	Less than 1 oz to several hundred pounds; usually less than 10 lb
Tolerances (avg, ±)	In in./ft: aluminum, 1/32; copper, 3/32; gray iron, 3/64; malleable iron, 1/32; steel, 1/16; magnesium, 1/32	**0.003 to 0.005 in./in.**	0.002 in./in. min for nonferrous alloys; 0.004 to 0.005 in./in. for ferrous alloys
Across Parting Line	Included above	**Add 0.005 to 0.015 in./in. to above**	Add 0.001 in./in. to above
Surface Finish, μin. rms	250-1000	**50-250**	10-85
Min Section Thickness, in.	Aluminum, 3/16; copper, 3/32; gray iron, 1/8; malleable iron, 1/8; steel, 1/4-1/2; magnesium, 1/32	**Same as green sand**	0.025 to 0.050
Max Section Thickness, in.	No limit in floor or pit molds	—	Normally 0.500

■ Shell mold casting is the process that uses a relatively thin-wall mold made by bonding silica or zircon sand with a thermosetting phenolic or urea resin. It has gained widespread use because these castings offer many advantages over conventional sand castings. Shell mold casting is a practical and economical way to meet the demand for weight reduction, thinner sections, and closer tolerances. The table below compares the shell process with sand and investment casting.

The same materials (with the exception of low carbon steel) can be cast by the shell molding process as are cast in green sand molds.

What are the advantages?

Use of the shell mold casting process provides five basic advantages.

1. Lower costs: high production rates and fewer finishing operations result in a lower unit cost for applicable parts.

2. Closer tolerances: shell castings are made to closer tolerances than sand castings.

3. Smoother surface finish: shell molding provides an improved surface when compared with sand casting (250-1000 μ in. rms for sand, 125-250 for shell).

4. Less machining: the greater precision of shell molding reduces and, in many cases, eliminates machining or grinding operations.

5. Uniformity: the insulating properties of the molds produce casting surfaces free of chill and with a more uniform grain structure.

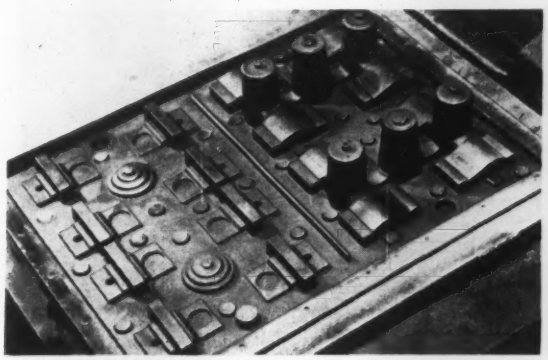
Although a shell mold is more expensive than a green sand mold, the possibility of reducing weight, minimizing machining and eliminating cores often results in savings sufficient to offset the mold cost.

Merely converting from sand to shell casting will not necessarily reduce costs. For an automotive

door hinge (see photo on facing page), shell castings cost about 40% more than sand castings. Cost of shell materials alone is over 2¢ per casting, no machining can be eliminated, and sand castings perform satisfactorily. No advantage is gained by converting parts such as these from sand to shell castings. Each prospective part must be accurately analyzed to determine whether the advantages inherent in shell casting will yield a finished part with the lowest cost.

Here's how the shell molding process works

Photos courtesy Westinghouse Electric Corp.



1 Pattern is made. *Match plate is made from tool steel with dimensions calculated to allow for subsequent metal shrinkage.*

2 Pattern is coated and heated. *Resin-sand mixture is applied to the metal pattern which is then heated to 425-450 F. Hot pattern melts the resin which flows between grains of sand and binds them together. Thickness of mold increases with time; after desired thickness is reached, excess unbonded sand is poured from pattern.*

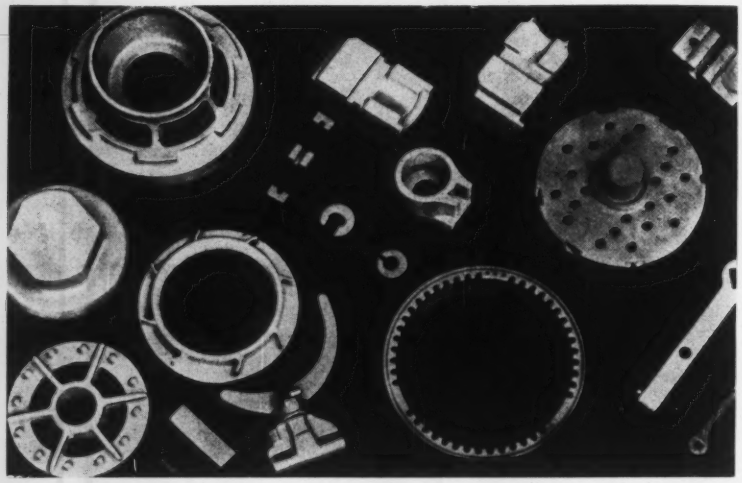
3 Shell is cured. *Pattern, with soft shell adhering, is placed in oven and heated to 1050-1200 F for 30 sec to 1 min. This cures the shell and produces a hard, smooth mold that reproduces the pattern surface exactly. Shell is stripped from the pattern by ejector pins. Other half of mold is produced the same way.*

4 Mold halves are prepared. *Spreads and risers are opened and cores are inserted to complete the cope and drag halves of the mold.*

5 Mold is sealed. *The two shell halves are glued together under pressure to form a tightly sealed mold. Mold can be stacked and stored indefinitely.*

Design: accuracy and tolerances

Accuracy of the shell mold process is about halfway between that of green sand and lost wax casting. Tolerances cannot be specified exactly because they depend on design factors, solidification characteristics of the alloy, pouring method (horizontal or vertical), and size of the casting. However, conversion of a casting from green sand molding to shell molding will improve dimensional properties and uniformity from piece to piece. The accompanying tables compare draft and some tolerances and allowances for sand and shell castings.



Parts of varying size, *shape and complexity can be produced by the shell molding process. The ring at the right center is approximately 8 in. in dia.*
Westinghouse Electric Corp.

DRAFT ALLOWANCES (Deg)

Process →	Green Sand	Shell
Normal	2	1
Minimum	1	¼
In Pockets	3-10	1-2

TOLERANCES FOR MALLEABLE AND GRAY IRON

Size of Casting, in.	Green Sand Castings, in.	Shell Castings, in.	
		Same Side of Parting Line	Across Parting Line
0-1	±0.023	±0.006	±0.010
1-2	±0.030	±0.012	±0.016
2-3	±0.030	±0.018	±0.022
3-8	±0.045	±0.030	±0.034
8-12	±0.060	±0.041	±0.045

Shell molded cores

An interesting offshoot of the shell molding process has been the development of shell molded cores. These cores have several important advantages over the sand cores which they replace: 1) the shell core usually costs less than the sand core; 2) strength and rigidity permit handling without damage or distortion; 3) sharp details, including threads, can be accurately reproduced; 4) weight of cores can be reduced; 5) cured cores are unaffected by moisture and can be stored for long periods of time; 6) most shell cores are hollow and can function as vents during casting.

To cite a specific example, one manufacturer of pipe fittings found that use of a shell core reduced the weight of one core from 350 lb in green sand to 100 lb. In addition, the greater accuracy of the shell cores allowed a 5-10% reduction in casting weight. Production increased 25% in tapping one specific fitting formerly cored with green sand cores; as an added bonus, tool life increased because of the reduction in the amount of burned-in sand.

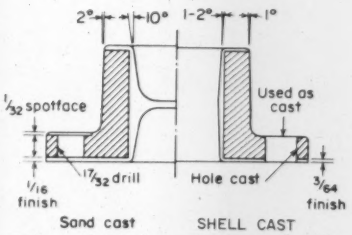
Photos Durez Plastics Div., Hooker Chemical Corp.

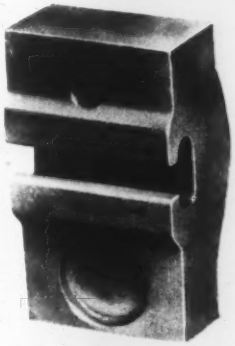
Shell molded cores *here are used in sand casting.*

Cores can be stacked *and stored for long periods.*

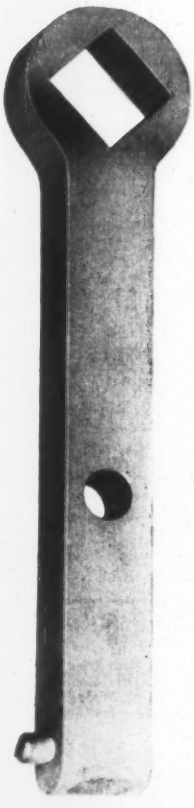
How shell castings minimize machining

Hub *cast in a shell requires less machining than a comparable sand casting. In the sand casting, considerable stock must be machined from the inside diameter because of the 10-deg draft angle and 1/8-in. web required. Also, the flange must be cast solid. Thus it is necessary to face the flange and drill the hole. In the shell casting the holes can be cast in place.* (General Motors Corp.)



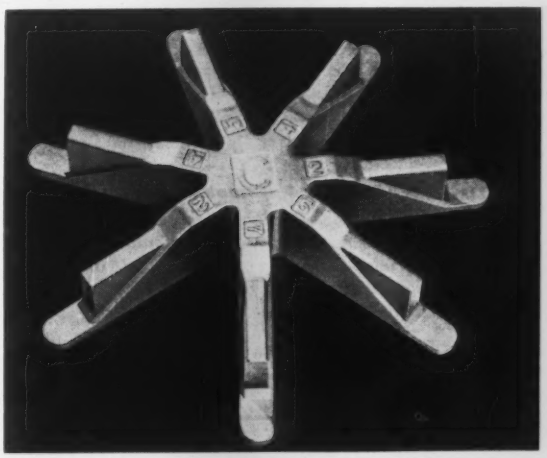


Cupaloy contact *was cast in a shell mold. Machining costs were reduced over 30% compared to a green sand casting. The part is used as the main contact in a circuit breaker and smooth surfaces are required for brazing.* (Westinghouse Electric Corp.)



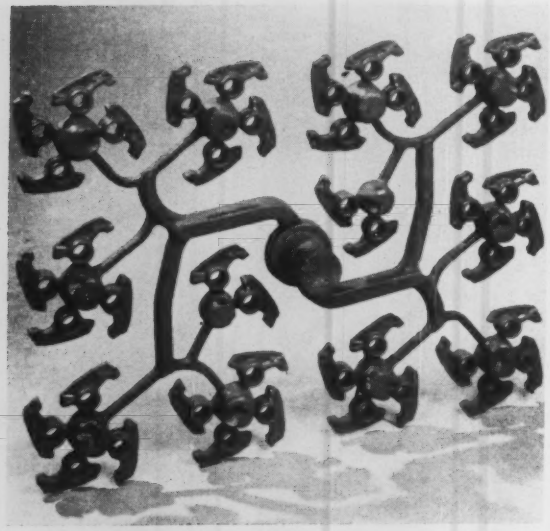
Flapper arm *of aluminum bronze needs no further machining after shell molding.* (Westinghouse Electric Corp.)

Simplex fifth wheel, *cast by Amer-Shell process, weighs 222 lb. No machining is required on either the bearing plate surface or the holes and locking contours.* (American Steel Foundries)

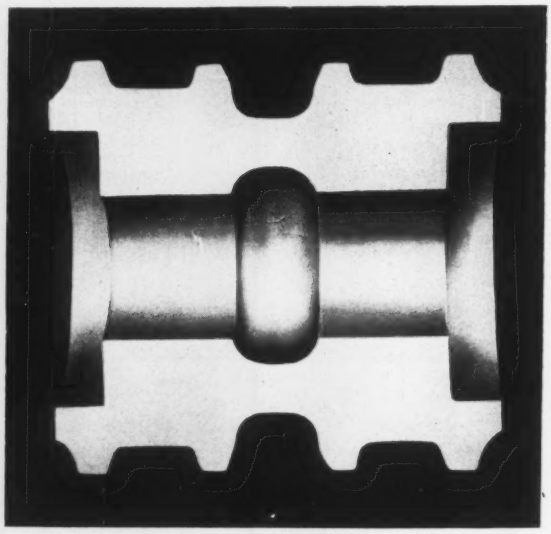


Radome hub *weighs 110 lb and is cast to a tolerance of ±0.010 in. Shell process eliminates the need to machine mating surfaces.* (American Steel Foundries)

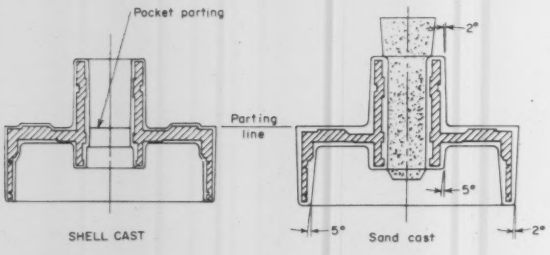
Four other ways to take advantage of shell molding



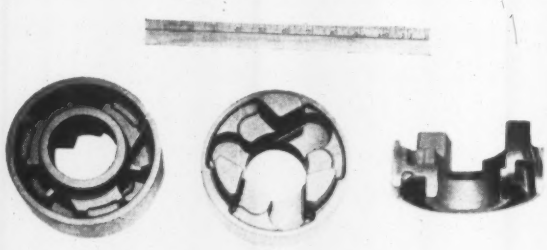
Reduce weight. ***Rocker arm*** *weighed 24% less when converted from green sand molding to shell molding. The hole, because of its depth and diameter, could not be cast in a sand mold. In the shell process the hole was cast and there was no need to machine the pad before grinding. The shell casting cost 10.4% more than the green sand casting. However, reduction in weight and increased accuracy resulted in a saving of ½¢ per finished part.* (General Motors Corp.)



Convert from a forging. ***Track roller*** *for a crawler tractor formerly consisted of two forgings welded together and machined. Shell casting eliminated the machining operations previously required on the welded assembly. Some machining operations were also eliminated on inside contours. Stock on other surfaces of this 200-lb casting was reduced from 0.090 in. to 0.030 in.* (American Steel Foundries)



Eliminate cores. ***Automotive part,*** *produced as a shell casting, needed no cores. Compared to sand casting: finish stock required for 100% cleanup in machining was reduced from 0.090 in. to 0.060 in.; draft angles were reduced; weight was reduced ¾ lb; and cost was reduced several cents per part.* (General Motors Corp.)

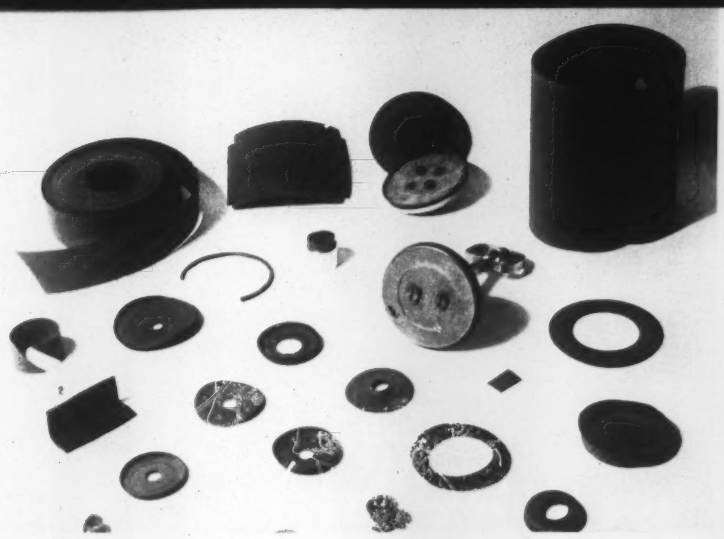


Produce complicated parts. ***Automotive transmission drums,*** *becoming more complex, have increased the need for the flexibility of shell molding. Improved surface finish makes it possible to justify the higher cost of shell molding on the basis of reduction in machining costs. An additional advantage is the freedom from surface sand—a characteristic of shell castings and an important consideration here because this part operates in a hydraulic medium.* (General Motors Corp.)

Acknowledgment

This article was developed after reading a paper given by Mr. C. Dale Evans, Central Foundry Div., General Motors Corp., to a Casting Design Conference held by his organization. Much of the information on automotive application was obtained from Mr. Evan's paper. The cooperation of the following companies is also gratefully acknowledged:

American Steel Foundries
Central Foundry Div., General Motors Corp.
Durez Plastics Div., Hooker Chemical Corp.
Westinghouse Electric Corp.



Economical parts from tape *include pump cups, seals, bearings, piston rings and gaskets.*

Do You Need Filled TFE? *Use Tape to Cut Costs*

Filled Teflon fluorocarbon resins are expensive. "Pay only for what you need" is the philosophy of designing with tape.

by Saul Ricklin,
Vice President–Development, Dixon Corp.

TYPICAL PROPERTIES OF TFE FLUOROCARBON—FILLED VS UNFILLED

Property	ASTM Method	Rulon[a]	Teflon[b]
PHYSICAL PROPERTIES			
Thermal Conductivity, Btu/hr/sq ft/°F/in.	Cenco-Fitch	2.3	1.7
Linear Coef of Ther Exp (−22 F to 86 F), per °F	D696-44	3.3×10^{-5}	7.5×10^{-5}
Water Absorption, %	D570-42	0.00	0.00
Flammability, ipm	D635-44	Noninflammable	Noninflammable
Specific Gravity	D792-50	2.20-2.25	2.14-2.20
MECHANICAL PROPERTIES			
Deformation under load (122 F, 1000 psi, 24 hr), %	D621-51A	2-4	3-6
Hardness			
Durometer	D676-55T	D60-75	D50-65
Rockwell	D785-51	R27-29	R15-17
Izod Impact Strength, ft-lb/in. notch	D256-56A	6.0	3.0
Stiffness in Flexure, 1000 psi	D747-50	75-100	50-90
Tensile Strength (rod), 1000 psi	D638-52T	1.4-1.5	1.5-1.8
Elongation (rod), %	D638-52T	50-200	75-200
Compressive Stress (1% offset), 1000 psi	D695-49T	2-2.4	1.0
Coef of Friction (at PV from 1000 to 20,000)		0.12-0.24	0.12-0.24
Resistance to Wear (PV range for unlubricated bearings)		5,000-20,000	1000
Operating Temp Range, F		−350 to 500	−350 to 500
ELECTRICAL PROPERTIES			
Dielectric Constant (60-10^{10} cps)	D150-54T	2.5-2.6	2.0-2.05
Dissipation Factor (10^3-10^{10} cps)	D150-54T	0.001-0.004	0.0003
Volume Resistivity, ohm-cm	D257-54T	1×10^{15}	1×10^{15}
Surface Resistivity (100% RH), ohm	D257-52T	2.0×10^{13}	3.6×10^{12}
Arc Resistance, min	D495-56T	3-4	Does not track
Dielectric Strength, v/mil			
0.80 In.	D149-44	400-500	400-500
0.010 In.	D149-44	900-1100	1100-1300
CHEMICAL RESISTANCE	Both materials have practically universal chemical inertness. Of the chemicals encountered in commercial practice, only molten sodium and fluorine (at elevated temperatures and pressures) show any signs of attack. Rulon is approved for use with liquid oxygen and high strength hydrogen peroxide.		

[a]Dixon Corp's trade name for filled TFE fluorocarbon plastic.
[b]Du Pont's tradename for TFE fluorocarbon (polytetrafluoroethylene).

■ Filled TFE fluorocarbon (Du Pont's Teflon) provides better wear resistance, reduced deformation under load, and lower thermal expansion characteristics than unfilled TFE (see accompanying table). Filled TFE fluorocarbon tape provides the same improved performance, but with a minimum of material. With the high cost of fluorocarbons, reducing the amount of material needed can substantially reduce costs.

Although on a weight basis tape made of Rulon (Dixon's tradename for filled TFE) costs about $9-10 per lb, parts can be produced at a cost of less than 3¢ per sq in. of 0.030-in. thickness; since 0.030-in. tape is replacing parts formerly molded of TFE in thicknesses of 0.30 in., costs in some cases are reduced by a factor of 10. Specific cost reductions possible, of course, depend on the application. At present,

tape is available in thicknesses of 0.004 to 0.125 in.

Parts are made by stamping or postforming the tape to the desired shape. In many cases TFE's plastic memory is useful in ensuring that the formed part provides a tight seal in service. The tape is being used for such applications as rotary and rod end seals, pump cups, bearings, piston rings, and wire insulation.

Lip seals

Stamped washers of Rulon tape can be formed into low cost lip seals. The material's memory ensures ideal sealing action, often making it possible to eliminate garter springs and associated hardware.

Pump cups (see photo) are an excellent example of benefits obtainable. Such cups operate from —400 to 550 F dry, or in almost any fluid without swelling or aging. Stick-slip and high breakaway force are eliminated. In a gasoline meter such cups eliminate the swelling experienced with leather cups, and initial cost of 3-in. cups made from 0.030-in. reinforced TFE is actually lower than that of leather cups.

In a 3-in. air cylinder 0.030-in. thick Rulon cups have replaced rubber cups. The new cups have been cycled over 4 million times at 90 psi over a temperature range of —50 to 160 F with no sign of failure. Switching to fluorocarbon cups has eliminated 1) low temperature shrinkage, 2) high temperature expansion and consequent sticking, and 3) the need for lubrication.

Rotary rod end seals can be formed simply by drawing out the i.d. of a washer over the rod to produce a hat-shaped seal. The material's memory again ensures a tight seal. The same technique can be used to form inexpensive valve stem packings.

Work is now underway to develop V-rings, U-cups and other lip seals by postforming tape.

Sliding surfaces

The extremely low friction that is characteristic of TFE can be put to use economically by using thin sections of the material on the surfaces of less expensive materials. In other words: pay for "slip" only where you need it.

Bearings made of thin 0.015 to 0.030-in. tape can be snapped into metal retainers. Such bearings offer the same excellent surface performance obtained with massive filled TFE bearings, but improve heat transfer, lower deformation under load, permit easy replacement, and lower cost.

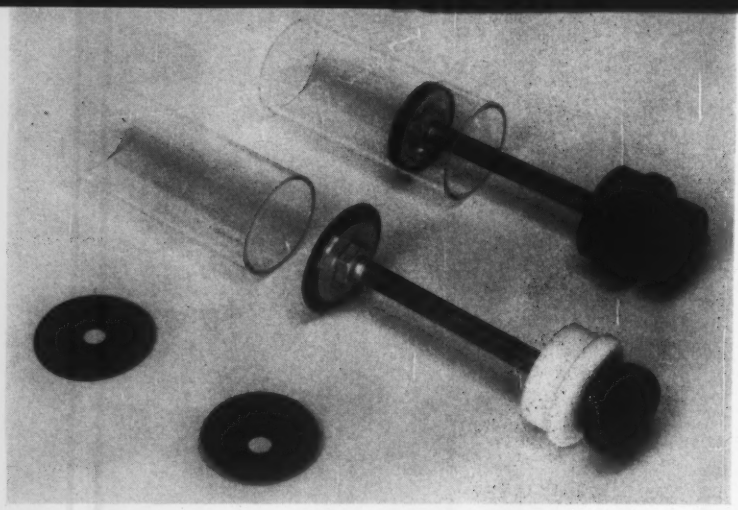
Snap-in bearings made of tape can be used unlubricated at a PV factor of 20,000 continuously, 50,000 intermittently; when lubricated, bearings can be operated at over 60,000 PV.

Tape-lined bearings (trademarked Rulon T-Liner) are available with press-fit steel retaining shells ranging in o.d. from ¼ to 1¼ in. Alternatively, retention can be built in by designing housing undercuts or shaft shoulders.

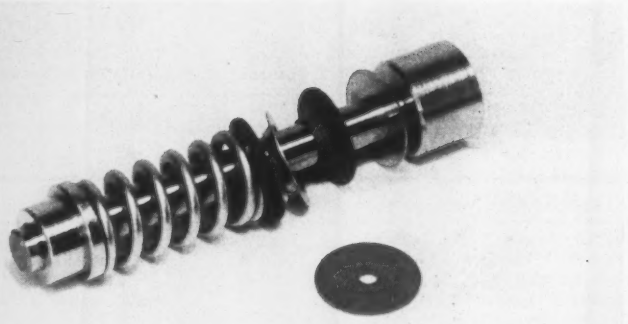
Present uses for such bearings include conveyors, sump pumps, washing machines and textile machinery.

Piston rings made of skived and slit tape 1/16 to 1/8 in. thick can be cut to length and wrapped around a piston ring groove to provide oilless cylinder operation. Such rings are low in cost, quiet in operation, and unaffected by most fluids.

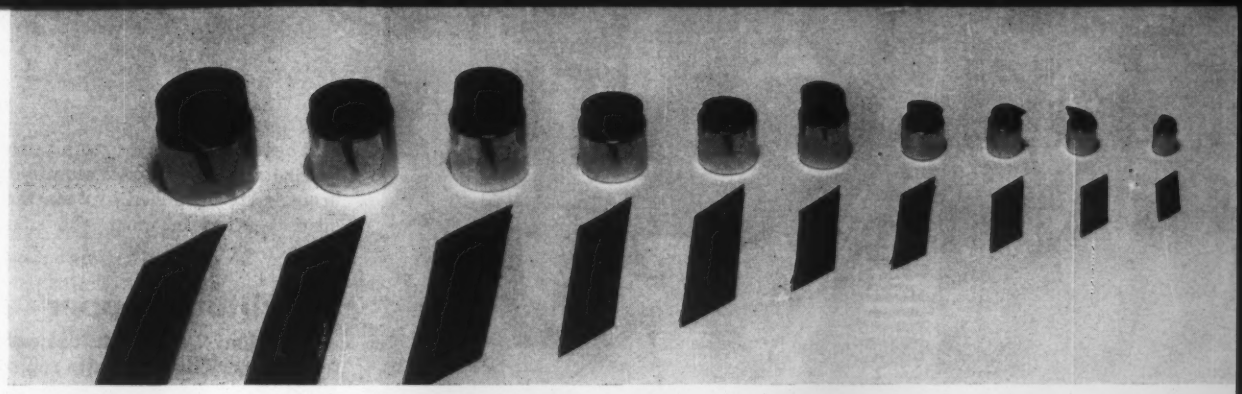
Bonded surfaces of filled TFE fluorocarbon can be provided by etching tape on one side to permit epoxy adhesive bonds providing tensile shear strengths as high as 1000 psi. Bonding tape to metal or wooden substrates provides low-friction wear surfaces useful for such parts as large roll support



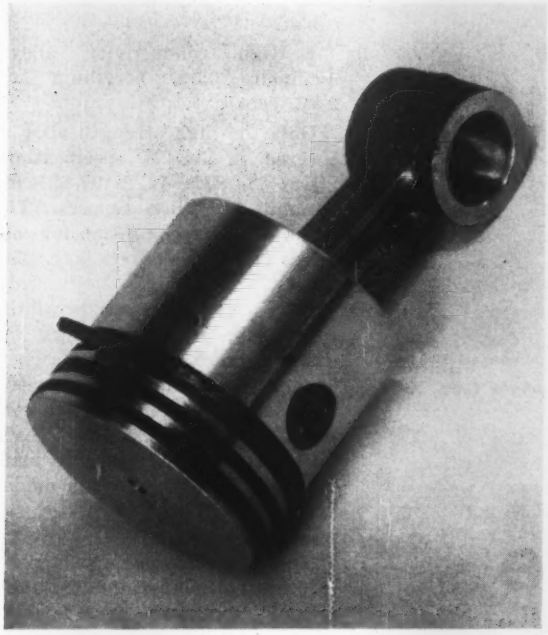
***Pump cups** are made by stamping washer, installing on piston, and inserting in cylinder. Memory of material ensures tight seal.*



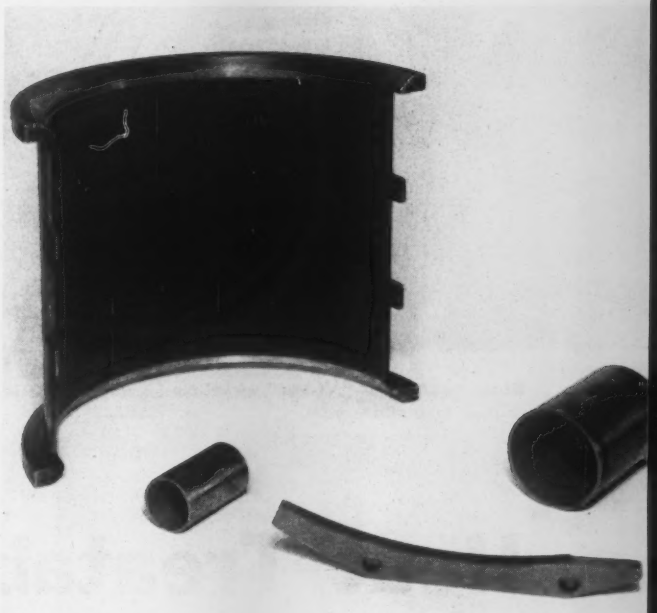
***Rotary rod lip seal** is simply formed from stamped washer by forcing i.d. over rod which draws washer out into hat section. Memory again ensures good seal around rod.*



Bearings *are produced economically by inserting slit and cut sections of tape.*



Piston rings *made from skived tape provide efficient unlubricated operation.*



Bonded surfaces *made of tape and adhered with epoxy adhesives include roll support half bearings, sleeve bearings and high speed loom wear surfaces.*

half bearings, sleeve bearings, and high speed sliding surfaces for looms and other textile equipment.

Other useful combinations include 1) bonding thin tape to rubber for seals, and 2) packings that combine the elasticity of rubber and the surface characteristics of filled TFE.

Filled TFE would not normally be thought of for uses such as clutch facings because of the material's low coefficient of friction. However, in specialty applications where operating temperature range is wide, wear is excessive, and smoothness of operation is mandatory, surfaces of bonded tape provide outstanding benefits. The fact that static coefficient of friction is lower than dynamic coefficient results in unusually smooth operation.

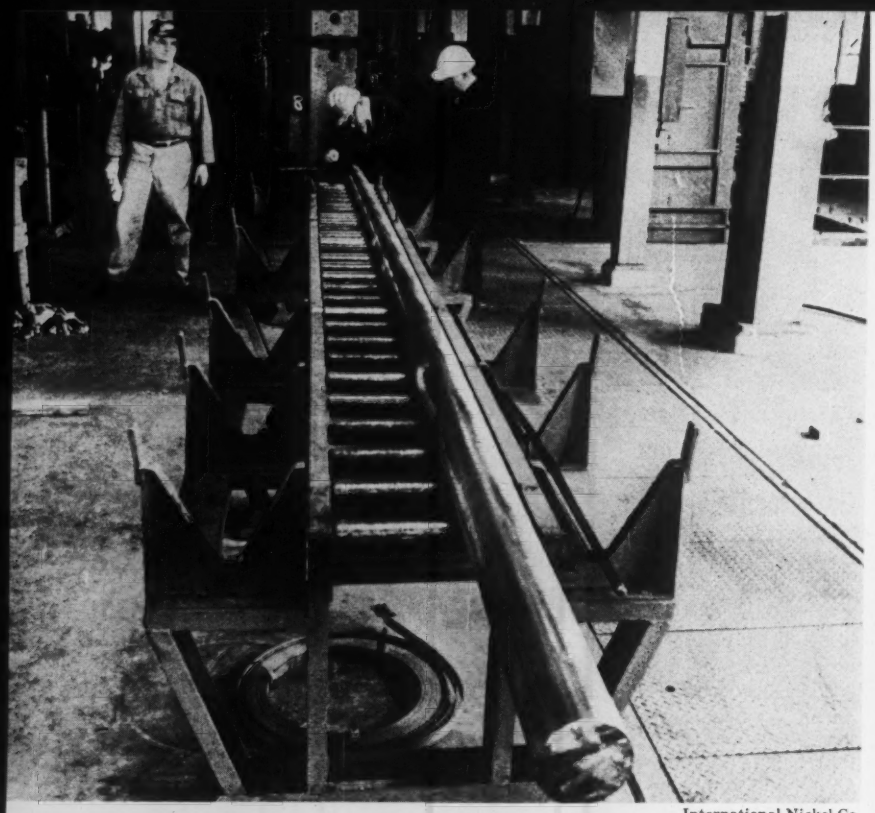
Wire insulation

As an abrasion barrier on high temperature insulated wire, filled TFE tape provides excellent resistance to abrasion and cut-through. In one application, wire to be used in missiles is constructed with a fused TFE primary insulation, and over-wrapped with 0.004-in. Rulon tape and a braided glass fiber outer jacket. After exposure of 100 hr at 750 F, abrasion resistance of the wire actually improves 20% over that of the original construction. Dielectric qualities also improve.

Other uses

A variety of other applications should develop where the characteristics of filled TFE fluorocarbon are required but economies call for use of the material in only thin sections. Some of these include:

- Tape back-up rings for o-rings. These have recently performed successfully at 600 F.
- Torque control bushings made from formed tape washers. They provide economical control for potentiometers and other devices.



International Nickel Co.

Stem casting *of "Ni-Vee" nickel-tin bronze is 20 ft long, weighs 1300 lb. It is part of a sluice gate.*

Heat Treatable Copper Alloys

for *High Conductivity* *Strength and Toughness* *Corrosion Resistance* *Wear Resistance*

by D. C. Ludwigson and R. J. Nekervis, *Battelle Memorial Institute*

■ Major commercial interest in heat treatable copper-base alloys centers around five alloy groups: beryllium copper, chromium copper, zirconium copper, nickel-tin bronze and aluminum bronze. The first three are high strength, high electrical conductivity alloys. Nickel-tin bronzes are applied as pressure tight fittings and heavy duty bearings. Aluminum bronzes have an impressive combination of toughness, corrosion resistance and wear resistance.

With the exception of aluminum bronzes, these copper-base alloys are heat treated by precipitation hardening. The duplex aluminum bronzes are hardened by a martensitic reaction in much the same manner as steel.

Beryllium copper

Beryllium coppers, basically ternary beryllium - cobalt - copper alloys, fall into two categories:

1. High strength alloys, nominally 2% beryllium and 0.5% cobalt.

2. High conductivity alloys, nominally 0.5% beryllium and 2.5% cobalt.

Only the high strength alloy is covered in ASTM specifications (B194-55, B196-52, B197-52) for wrought beryllium coppers. The broad ASTM specification for cast alloys (B119-45) covers both alloy types.

Cobalt is added to beryllium coppers in order to reduce the solubility of beryllium in copper. This, in turn, improves conductivity, increases service temperatures, and reduces alloy costs. Nickel is sometimes used in place of cobalt but its effect is not as pronounced.

Heat treatment

The alloys are usually supplied in the soft, formable solution treated condition for forming prior to aging. High strength alloys are solution treated at 1450 F and high conductivity alloys at 1700 F, followed by water quenching. After solution treatment, depending on strength and fabrication requirements, the alloy is aged either with or without a prior cold working treatment. The effect of combined heat treatments and cold working on various beryllium copper alloys is shown in Table 1.

Special heat treatments: For close dimensional control, beryllium copper is aged while clamped to a form or jig. When close control over final properties is required, it has been suggested that pilot samples be heat treated for better control of final properties. It has also been suggested that fatigue life is improved by aging the alloy in vacuum.

Surface hardening thick sections is accomplished by holding the part at 1000 F for an extended period. After aging, heating the surface rapidly to 1500 F by flame or induction heating, then water quenching, causes only the surface to be hardened.

Applications

The first, and still the largest, uses for high strength beryllium copper are current-carrying springs, contacts and clips. The alloys are ideally suited for these applications because of their combination of strength and conductivity.

Other properties of this alloy group of interest to engineers: the alloys are nonmagnetic, have excellent fatigue strength and corrosion resistance, and exhibit low hysteresis and minimum elastic lag.

Some applications are:

1. High strength and conductivity: current-carrying springs, both helical and flat. Helical springs are used largely as brush springs in electric motors. Flat contact springs for computers are the largest single use for these alloys. Flat contact springs are also used in electric shavers, microswitches, automobile ignition parts, tube sockets and fuse clips.

2. Nonsparking characteristics and corrosion resistance: tools. Such tools are used in areas where explosion hazards exist. Boat owners have adopted beryllium copper tools because of their durability in salt atmospheres.

3. High strength, wear resistance and shock resistance: gears, bushings, bearing and pump parts. The alloys have good resistance to wear, galling and abrasion, especially in contact with hardened steel. Resistance to shock and vibration is particularly important in bushings for reciprocating aircraft engines. In addition, the corrosion resistance of beryllium copper makes it suitable for parts in pumps handling brackish waters and certain other corrosive liquids.

TABLE 1—EFFECT OF THERMAL AND MECHANICAL TREATMENTS ON SOME BERYLLIUM COPPER ALLOYS

Composition, %	Form	Condition[a]	Soln Treat Temp, F	Aging Treatment	Ult Ten Str, 1000 psi	Yld Str (0.6 offset), 1000 psi	Elong (in 2 in.), %	Elec Cond, % IACS
Be 2.00-2.25, Co 0.35-0.65	Castings	As Cast	—	—	70 min	40 min	15 min	15 min
		T	—	3 Hr, 650 F	85 min	45 min	15 min	18 min
		A	1475-1500	—	55 max	20 max	30 max	15 min
		AT	↓	3 Hr, 650 F	155 min	115 min	0 min	18 min
Be 1.80-2.05, Co 0.18-0.30	Strip	A	1450-1475	—	60-78	28-36	35-60	17-19
		½ H	↓	—	85-100	75-90	5-20	15-17
		H	↓	—	100-120	95-112	2-7	15-17
		AT	↓	3 Hr, 600 F	165-190	130-150	3-10	22-25
		½ HT	↓	2 Hr, 600 F	185-210	160-185	1-5	22-25
		HT	↓	2 Hr, 600 F	190-215	160-185	1-3	22-25
	Rod	A	1450-1475	—	60-85	20-30	35-60	17-19
		½ H	↓	—	85-130	75-105	10-20	15-17
		AT	↓	3 Hr, 600 F	160-190	145-175	4-10	22-25
		½ HT	↓	2 Hr, 600 F	185-215	170-200	2-5	22-25
	Wire	A	1450-1475	—	60-80	20-30	35-55	17-19
		½ H	↓	—	110-135	90-110	2-8	15-17
		AT	↓	3 Hr, 600 F	160-190	145-175	3-8	22-25
		½ HT	↓	2 Hr, 600 F	190-230	185-220	1-3	22-25
Be 1.60-1.80, Co 0.18-0.30	Strip	A	1450-1475	—	60-78	28-36	35-60	17-19
		½ H	↓	—	85-100	75-90	5-20	15-17
		H	↓	—	100-120	95-112	2-7	15-17
		AT	↓	3 Hr, 600 F	150-180	120-145	3-10	22-25
		½ HT	↓	2 Hr, 600 F	170-195	150-175	1-5	22-25
		HT	↓	2 Hr, 600 F	180-200	150-175	1-3	22-25
Be 0.40-0.70, Co 2.35-2.70	Strip	A	1650-1700	—	40-55	20-30	20-35	20 min
		H	↓	—	70-85	60-80	5-8	25 min
		AT	↓	3 Hr, 900 F	100-120	70-90	8-15	45 min
		HT	↓	2 Hr, 900 F	110-130	105-120	5-12	48-52
	Rod	A	1650-1700	—	40-55	20-30	20-35	25-30
		½ H	↓	—	60-80	55-75	10-15	22-27
		AT	↓	3 Hr, 900 F	100-120	80-100	10-25	48-60
		½ HT	↓	2 Hr, 900 F	110-130	100-120	8-20	48-60
Be 0.25-0.50, Co 1.40-1.70	Rod[b]	A	1700	—	40-55	20-30	20-35	25-30
		½ H	↓	—	60-80	55-75	10-15	22-27
		AT	↓	3 Hr, 900 F	100-120	80-100	10-25	50-52
		½ HT	↓	2 Hr, 900 F	110-130	100-120	8-20	50-52

[a] A = annealed; H = hard; T = tempered. [b] Contains 0.9-1.1% silver.

4. Wear resistance: forming and draw dies. Such dies have been made for both steel and titanium. The resistance of these dies to wear, seizing, and galling results in consistently smooth surfaces on manufactured items and reduced polishing costs.

5. High hardness: forging and plastic molding dies. The high hardness and excellent detail obtained in cast beryllium copper dies make them suitable for forging light metal alloys. In plastic molds, beryllium copper's high thermal conductivity and good impact resistance permit higher production rates than possible with steel molds. In addition, molds may be stored without protection against corrosion.

6. High strength and corrosion resistance: bolts. In fuel injection systems for aircraft engines, steel bolts tend to seize because of corrosion by fuel; beryllium copper bolts do not.

7. High conductivity: resistance welding electrodes. Although copper and silver have the necessary conductivity and phosphor bronze the required strength, none has an adequate combination of these properties for use as resistance welding electrodes, holders, jaws and soldering iron tips.

TABLE 2—EFFECT OF HEAT TREATMENT AND COLD WORK ON CHROMIUM COPPER[a]

Rolled or Drawn, %	Condition	Ult Ten Str, 1000 psi	Yld Str (0.5% proof), 1000 psi	Elong (in 2 in.), %	Elec Cond, % IACS
SHEET[b]					
0	Soft	34	19	41	40
14	As Rolled	39	37	19	40
	Aged[c]	57	46	18	80
32	As Rolled	47	45	7	40
	Aged[c]	64	55	16	80
51	As Rolled	54	51	6	40
	Aged[c]	67	59	14	80
70	As Rolled	58	55	6	40
	Aged[c]	73	65	13	80
ROD[d]					
0	Soft	45	14	40	34
60	As Drawn	62	59	11	34
	Aged[c]	73	65	17	76
80	As Drawn	70	64	7	34
	Aged[c]	79	72	15	76
90	As Drawn	74	74	5	34
	Aged[c]	86	—	13	76

[a]Composition, %: 0.7-1.0 Cr, 0.1 Si, 0.08-0.12 Ag. [b]Soln treated ¾ hr at 1825 F. [c]3 hr at 850 F. [d]Soln treated ½ hr at 1832 F.

TABLE 3—EFFECT OF HEAT TREATMENT ON NICKEL-TIN BRONZES

Composition, %					Condition	Tempering or Aging Treatment	Ult Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (in 2 in.), %
Cu	Ni	Sn	Zn	Pb					
88	5	5	2	—	As Cast		50	22	40
					Tempered	6 Hr, 600 F	65	40	10
					Soln Treated[a]	6 Hr, 600 F	85	55	8
80	5	5	5	5	As Cast		40	20	15
					Tempered	6 Hr, 575 F	50	30	5
78	5	5	2	10	As Cast		35	20	10
					Tempered	6 Hr, 575 F	40	25	2
68	5	5	2	20	As Cast		25	18	10
					Tempered	6 Hr, 575 F	30	22	5

[a]6 hr at 1400 F then tempered as shown.

Chromium copper

Chromium coppers are chiefly wrought alloys containing about 1% chromium and 99% copper. The alloys may also contain small amounts—on the order of 0.1% —of silicon and silver to emphasize the precipitation hardening effect or improve elevated temperature strength.

As aged, chromium copper exhibits twice the strength of copper and retains 80% of its conductivity. It is used where the high electrical and thermal conductivities of pure copper are required in combination with greater strength. Castings are sometimes used for elevated temperature applications when inhibition of grain growth is required.

Heat treatment

Chromium copper is normally solution treated at 1825 F and water quenched. In the solution treated condition, the mechanical properties are similar to those of copper, allowing the alloy to be easily shaped. Strength is increased by subsequent aging 3 hr at 850 F.

Greater strengths are obtained after aging, however, if the material is cold worked before fabrication. Table 2 shows the effect of both aging and cold work on chromium copper.

Applications

High electrical and thermal conductivities, good strength, and resistance to softening in continuous service at temperatures up to 750 F, combine to make the alloy an excellent material for such resistance welding components as spot welding electrodes, and seam welding rolls, wheels and tips. Chromium copper is also used for electrode holder jaws and cable connectors.

Other applications: circuit breaker parts, grid supports and commutators for electric motors. Rolled-in subsurface scale, which is difficult to detect, is reported to have caused some difficulties in the commutator application.

Zirconium copper

Zirconium copper, a wrought, high conductivity alloy developed especially for motor commutators subjected to high stresses or vibration at elevated temperatures, contains 0.10 to 0.15% zirconium. This alloy was recently described in M/DE ("Three New Copper Alloys with High Conductivity," May '60, p 16). In addition to its high conductivity level of 95% IACS, its most important attribute is the ability to resist softening after prolonged exposure to temperatures up to 930 F.

Heat treatment

After solution treatment at 1400 F, the alloy is cold reduced 60% and aged at 800 F. Relief of working stresses during aging somewhat counterbalances the hardening due to precipitation. Conductivity increases from 89% for the solution treated alloy to 96% for the aged material.

Applications

The alloy is used primarily where these design features are important:

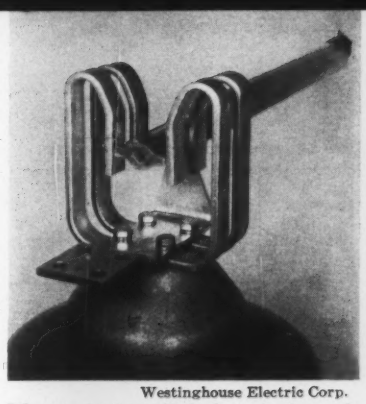
1. Excellent electrical conductivity.
2. Good mechanical properties.
3. Resistance to softening at temperatures up to 930 F. (Copper, silver-bearing copper and chromium copper soften at much lower temperatures.)

Although the principal use of zirconium copper is in commutator segments, it is also being used for slip and collector rings, resistance welding electrodes, soldering tips, and electronic tube supports.

Nickel-tin bronze

These alloys are modifications of the cast gun metals in which half the tin content is replaced by nickel. Nominal composition is: 5% tin, 5% nickel, and 2 to 5% zinc. Lead ranging from 5 to 20% is sometimes added.

When lubrication is satisfactory, the constructional, or lead-free, alloys provide the best combination of strength and resistance to seizure, galling and wear when in contact with hard materials. Lead-

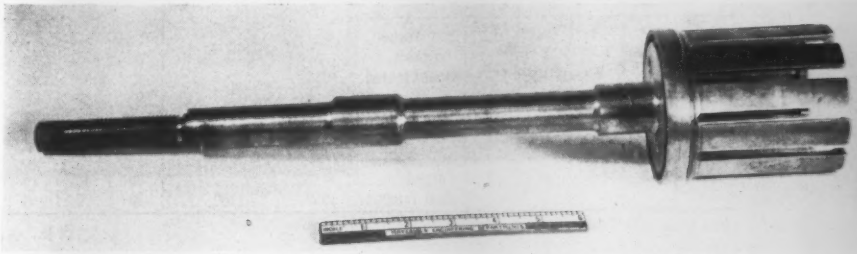


Westinghouse Electric Corp.

Disconnect switch jaw *is formed from zirconium copper alloy strap.*

Copper & Brass Research Assn.

Water box *of aluminum bronze, 106 in. in dia, is installed on condenser shell for oil refinery service.*



Westinghouse Electric Corp.

Circuit breaker contact *is sand cast from chromium copper alloy.*

ed alloys find greater application as severity of bearing or machinability requirements increases. For example, the alloy containing 20% lead is the best one to apply from the machinability standpoint; it is also able to withstand such unfavorable bearing conditions as misalignment, deformation and poor lubrication. This alloy, however, has only half the strength of the lead-free grade.

Heat treatment

Nickel-tin bronze castings may be used as-cast; a more common treatment is to harden by aging at 550 to 650 F. Lead-free alloys can be solution treated at 1400 F and quenched prior to aging if the highest strength is required. Some illustrative heat treatments and resultant mechanical properties are shown in Table 3.

Applications

The entire range of nickel-tin bronzes is highly resistant to corrosion by a wide variety of gases and liquids (including sea water and industrial atmospheres). Resistance to stress corrosion cracking is especially high.

Because of resistance to wear and galling, lead-free alloys are often used for gears, cams, valves, guides, wear plates and allied parts in drive and control systems. High corrosion resistance also makes these alloys suitable for pump parts in corrosive liquid environments. Highly leaded nickel-tin bronzes are used for the most severe bearing applications.

Pressure castings for fittings in plumbing and hydraulic systems use 5% lead alloys because of their pressure tightness, good strength, corrosion resistance and excellent machinability. The 5% lead alloys are also used for bearings.

Aluminum bronze

Commercial duplex aluminum bronzes contain about 10% aluminum. These alloys exhibit a martensitic transformation, and in many ways their behavior is analogous to steel. The duplex alloys are difficult to work cold but are easily hot worked and have good casting qualities. The alloys are described by two ASTM specifications: B148-52 (cast) and B150-54 (wrought).

In addition to copper and aluminum, the alloys may contain iron and nickel up to 5%. These two elements retard grain growth at

TABLE 4—EFFECT OF HEAT TREATMENT ON SEVERAL ALUMINUM BRONZES

Composition, %					Form	Soln Temp, F	Tempering Temp, F	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %
Cu	Al	Fe	Ni	Mn						
87.5	9	3.5	—	—	Cast			75	27	35
89	10	1	—	—	Cast			67	32	15
					Heat Treated	1625	1125	90	40	15
83 min	10-11.5	3-5	2.5 max	0.5 max	Cast			75	35	18
					Heat Treated	1625	1000	105	52	10
81	11	4	4	—	Cast			95	45	7
					Heat Treated	1625	1150	115	70	5
90.3	9.4	—	—	0.2	Hot Worked, Drawn			75	35	28
					Heat Treated	1650		109	28	29
							750[a]	109	30	29
							1110[a]	101	35	34
							1200[a]	94	33	48
81	10	2.5	5	1	Forged			80	45	10
					Heat Treated	1650	1100	90	70	3

[a]For 1 hr.

elevated temperatures, improve hardenability, and improve corrosion resistance. Iron also improves wear and abrasion resistance.

Three other alloying additions are used: manganese, primarily as a deoxidant but also to improve strength; lead, sometimes, to increase machinability; silicon, in amounts up to 2%, to improve strength, hardness, machinability and wear resistance. Silicon also reduces the coefficient of friction with steel.

Heat treatment

Heat treatment of duplex aluminum bronze is similar to that of steel. Alloys are usually hardened by quenching from 1450 to 1650 F and then tempered. Up to approximately 700 F, tempering increases strength and reduces ductility. Above 700 F the reverse is true. Table 4 lists mechanical properties of several aluminum bronzes, both as-cast and heat treated.

Bibliography

The authors have agreed to send a 200-reference bibliography to interested readers. Write to: Mr. D. C. Ludwigson, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

Applications

1. *Corrosion resistance and high strength:* Parts such as chains, hooks crates and racks for use in sulfuric acid pickling of ferrous and nonferrous products are made of duplex aluminum bronze. Pump parts and fan blades coming into contact with acid or acid vapors are frequently made of aluminum bronze.

The material is also used for beater bars and blades of pulping machines for the paper industry, which must have good strength as well as resistance to attack by sulfite solutions. This strength plus corrosion resistance also finds use in water works and sewage works equipment.

Other uses: pump parts, shafts, valve fittings, bolts, etc. Aluminum bronze which contains nickel is well-known as a marine propeller and shafting material because of its strength and resistance to cavitation attack.

Because of resistance to sea water, duplex aluminum bronzes are popular for many other marine applications.

2. *Heat resistance:* Because they maintain strength well at temperatures up to about 600 F, these alloys find applications as valve seats, valve guides, small cylinder heads and spark plug components. Resistance welding jaws and clamps have also been fabricated from aluminum bronze.

3. *Bearing qualities and wear resistance:* When these two properties are the principal design criteria, the alloys have been specified for wear plates, bushings, guides, gears, feed nuts and worms. Such components are used in the screw-down mechanisms of large rolling mills, and perform well even when poorly lubricated.

Forming dies for carbon steel, stainless steel, zinc and aluminum take advantage of the hard, slippery, self-healing oxide film that forms on the die surface and helps reduce die wear and friction loss.

Although the core of aluminum bronze dies is usually strong enough to withstand heavy compressive loads without yielding, the dies are sometimes backed up by steel sections.

4. *Nonsparking qualities:* Safety tools used in the paint and explosives industry are often made from these alloys. The tools include wrenches, hammers, shovels and knives. When great hardness or a cutting edge is required, however, beryllium copper tools are preferred. To help reduce costs, aluminum bronze tools with beryllium copper inserts may be used in such situations.

5. *Low unit weight and good damping qualities:* Duplex aluminum bronzes are the least dense (specific gravity 7.6) of the copper-rich alloys. This characteristic, in combination with vibration damping qualities and wear resistance has led to the use of these alloys in aircraft parts such as propeller shaft bushings.

MORE ENGINEERING & DESIGN

Superconductive domains... 105
Weight penalties..... 105
Ceramic lubricants 110
Ultrasonics for tinning..... 112
Multiple creep tester..... 116
Sleeves speed assembly.... 118

Flight Propulsion Div., GE

M/DE Manual
No. **179**
January, 1961

Creep test *at 2000 F is run in this capsule test equipment.*

What You Should Know About

Creep-Rupture

Creep and stress-rupture data are needed in designing high temperature equipment. But it is dangerous to use such data without understanding how it was obtained and how it can be affected by variations in materials, processing and service conditions. This article tells about:

Stress, temperature and time
Sensitivity and scatter
The three types of high temperature alloys
Effects of heat treatment and cold work

by F. J. Clauss, *Missiles and Space Div., Lockheed Aircraft Corp.*

■ How do metallurgical factors affect the deformation and failure of metals at elevated temperatures. To know this is important. First, it is necessary if we are to appreciate current theories of creep-rupture (and the complexities that make adequate theoretical treatment difficult). But of more practical importance, it is necessary if we are to understand and control the behavior of metals and alloys in high temperature applications.

Consider for a moment a few of the complexities of creep-rupture behavior. Since deformation and failure occur both within the grains and along grain boundaries, the relative strengths of the crystalline and grain boundary material are important, as are their variations with temperature. Metallurgical structures change with time and with deformation at elevated temperatuures because of strain hardening, annealing, precipitation hardening, overaging and other effects. These structural changes can take place both before and during creep-rupture and can affect strength in opposite ways. As a result, creep-rupture behavior at elevated temperatures is very sensitive to the stress and temperature of testing and to small changes in the materials and their conditions. Melting and casting techniques, forging practice, grain size, prior cold working, etc. can be more important than chemical composition; control of these factors can be more important than the choice of alloy.

What is creep-rupture?

Creep-rupture behavior is best illustrated by the idealized curve in Fig 1, which shows graphically how a metal elongates under a constant tensile load at elevated temperatures. After an immediate extension upon the application of the load (A), the material continues to deform with time and eventually fails.

Creep is the time-dependent deformation under load (from A to D in Fig 1) and can be divided into three more or less distinct stages:

Primary creep (B)—Rate of creep (slope of the creep curve in Fig 1)

continually decreases; i.e., creep resistance increases. The increase in strength is due to the work or strain hardening that accompanies the elongation, similar to the effects of cold working metals at lower temperatures.

Secondary creep (C)—Creep rate remains constant. This stage represents a running balance between strengthening the material by work or strain hardening and weakening by thermal softening. The rate of creep is a minimum—less than during the primary and tertiary stages. Depending upon conditions, this period can appear as a long straight-line portion on the creep curve in Fig 1 or simply as a point of inflection on the curve.

Tertiary creep (D)—Period of imminent failure, during which the creep rate increases rapidly. Accelerated creep is due to 1) the increase in stress that accompanies the necking-down of a specimen under a constant tensile load, 2) to metallurgical instabilities or structural changes that weaken the material (e.g., recrystallization or overaging of precipitates), 3) to the formation of cracks in the grains or along the grain boundaries (which can occur as a result of the migration and coalescence of vacancies generated by dislocation motion during creep), or to a combination of all three.

For practical purposes strength can be expressed as either resistance to creep or resistance to rupture. The choice depends upon whether a part must not deform more than a certain amount or simply must not fracture completely for given conditions of stress, temperature and lifetime. Convenient measures of high temperature strength include:

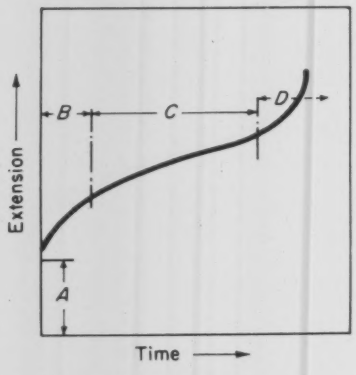
Minimum creep rate—Rate of creep during the secondary stage at a specified stress and temperature.

Creep strength—Stress, at a specified temperature, required to cause either a specified minimum creep rate or a specified amount of creep in a given time.

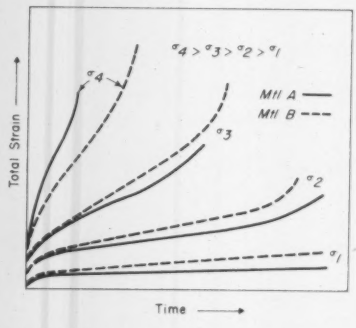
Rupture life—Time to rupture at a specified stress and temperature.

Rupture strength—Stress, at a specified temperature, required to cause rupture in a given time.

Values for creep-rupture strength can be given either in tabular or graphical form. The figures that accompany the text illustrate some of the graphical ways in which this information is presented.



1—*Schematic of a typical plot of creep data.*



2—*Effect of stress on creep strength at a constant temperature.*

Three criteria: stress, temperature, time

Stress and temperature

In comparing the creep-rupture behavior of different alloys, or of different metallurgical conditions of the same alloy, the particular criterion used for comparison is all-important. An alloy that is better than another under one set of conditions can be much poorer than the other under a different set of conditions.

Fig 2 shows creep curves for two materials at a single temperature and for a series of stresses ranging from a low of σ_1 to a high of σ_4. Although material *A* is stronger at σ_1, as stress increases to σ_4 the relationship changes, and at the highest stress *B* is obviously the stronger material. A similar variation can be shown by holding the stress constant and varying the temperature.

Effect of cold work depends on temperature—Fig 3 illustrates the importance of the criteria used in evaluating a specific material and metallurgical factor—in this case, AISI 347 stainless steel subjected to varying amounts of cold work. The effect of cold work on rupture strength was judged on the basis of the stress required to cause rupture in 10, 100 and 1000 hr at temperatures of 1200, 1300 and 1500 F.

Note that at the lowest temperature and shortest time to rupture (1200 F and 10 hr), strength increased progressively with the amount of cold work; 30% reduction in area improved the strength at these conditions by almost 50% over that for the annealed condition. At the same temperature but a longer time to rupture, 1000 hr, the increase in strength was less significant. At a higher temperature, 1300 F, cold work improved the strength for rupture in 10 hr but had no significant effect—and possibly caused a slight reduction in strength—at 1000 hr to rupture. At a still higher temperature, 1500 F, rupture strength was lowered by prior cold work.

Thus, a statement that cold work increases (or decreases) the rupture strength of this steel is incomplete and can be dangerously misleading. The statement should include the criteria used for passing judgment—in this case, the stress for a specified time to rupture, the temperature, and the amount of cold work.

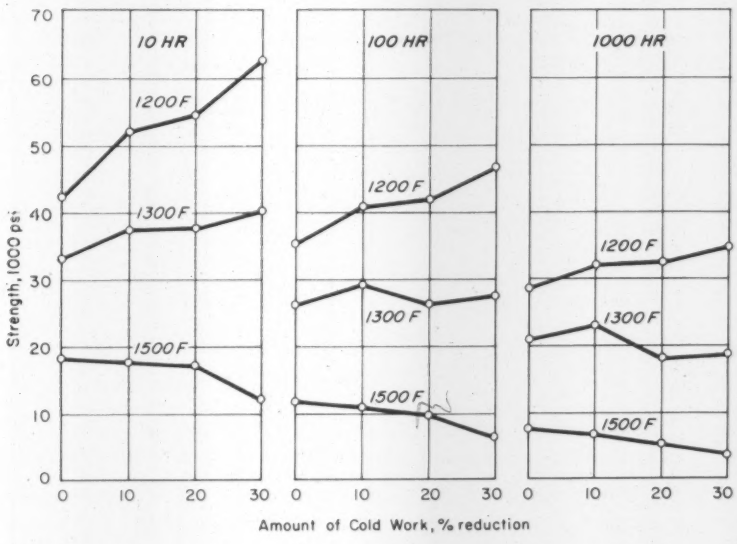
Time

Different engineers will adopt different time criteria, depending upon the applications for which a material is intended. When close tolerances must be maintained, the time it takes to creep or elongate a specified amount such as 0.1% or 0.2%

may be important. When intended service life is very long, as in power plants where a life of 30 to 40 years is common, a minimum creep rate is determined so that the product of the creep rate and service life does not exceed the allowable amount of deformation. In such cases the stress corresponding to that creep rate at that service temperature (minus a safety factor) is taken as the maximum allowable design stress. Other applications such as reactor vessels may only require that the part does not fracture in service, in which case time to rupture is the important criterion.

Use realistic criteria—Service life may be a matter of years, as in industrial plants and equipment; or a matter of seconds, as in rockets and missiles. Since the structural changes that occur at high temperatures are sensitive to time as well as temperature, it is important to use times that are realistic for the intended application. Tests on a material for use in power-plant piping should be run for times longer than 1000 hr. But 100 hr is sufficient for materials used in turbine blades for military turbojet planes, and 1 min is sufficient for some rocket nozzles.

When it is impractical to run tests for the full service life, tests are often run at higher temperatures and stresses so that failure occurs within a reasonable test period; data are then extrapolated to the desired stress and temperature (for a comparison of several methods, see M/DE, Apr '59, p 93). In such cases, higher temperatures and stresses simulate the structural damage caused by running for longer times at the lower values, although the correlation may not be perfect.



3—*Cold work has varying effect on rupture strength, depending on test temperature.*

Sensitivity and scatter: use data carefully

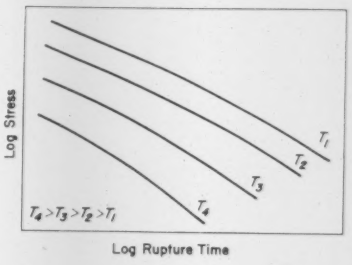
Both sensitivity and scatter present the engineer with a serious problem. Each application must be considered in the light of metallurgical changes which can be induced by minor changes in stress, temperature and time of application. Similarly, the wide range over which test data can vary, even for material taken from the same heat, requires rigid statistical control to develop reliable creep-rupture properties.

Sensitivity

Generalizations on how changing the stress or temperature affects creep rate, time to rupture, etc. are dangerous. At best, only a rough order of magnitude can be given, but this should be enough to emphasize the importance of controlling closely the stress and temperature during testing in order to get reliable data and to point out the consequences of overheating and overstressing in actual service.

Small changes, large effects—For many steels and cobalt-base and nickel-base alloys, a change in temperature of 100°F changes the time to rupture by a factor of about 10. If creep-rupture data are plotted as in Fig 4, with the time to rupture on a logarithmic scale, the isothermal curves will be separated from each other by about 1 cycle on the time scale for each 100°F difference. Thus, if the life of a material is 100 hr at a certain stress and temperature, then the life at the same stress but 100°F higher will be about 10 hr. This is only an approximation; more exactly, the factor depends on the material, the stress and the temperature.

The effect of changes in *stress* varies still more widely with material, stress and temperature. For example, Inconel X has a rupture life of about 100 hr at 30,000 psi and 1500 F; increasing the stress to 33,000 psi at the same temperature reduces the life to 50 hr—a 50% reduction in life for a 10% increase in stress. In other cases the effect is



4—*Conventional plot of creep-rupture data shows the relationship between stress, time to rupture and temperature (T).*

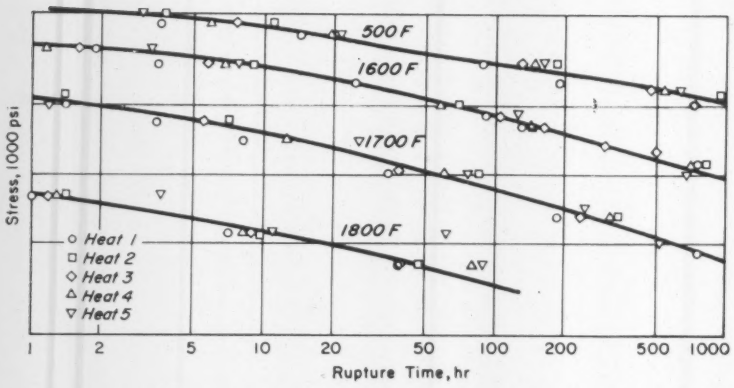
still more pronounced. It is characteristic of most materials that the slopes of the stress vs time-to-rupture curves on the conventional log-log plots (as in Fig 4) are rather shallow, and thus that a small change in stress causes a large change in the time to rupture.

When stress and temperature are not constant — Most engineering structures designed for high temperatures must withstand loads and temperatures that usually vary with time. These variations may be temporary excursions or part of a prescribed operating cycle. For example, many processes in chemical plants and petroleum refineries are cyclic; the equipment operates for a period of time at one set of pressures and temperatures and then switches to a different set of conditions. Shutdowns for maintenance are also regularly scheduled. Examples of unscheduled variations are common in gas turbines, where stresses and temperatures fluctuate as the power requirement changes. In the majority of all designs overloads and overtemperatures must be anticipated.

The creep rate of steels can be markedly increased by small temperature variations. In 1942, Fellows, Cook and Avery reported tests on a 26% chromium–12% nickel steel in which one specimen was held at a constant temperature of 1800 F and a stress of 3000 psi while a second specimen was cycled 10°F above and below 1800 F on a 7-min cycle while under the same stress. The average creep rate of the second specimen was more than six times that of the first. It was greater, in fact, than if the first specimen had been tested at 1810 F, which was the upper limit of the variation.

Even greater weakening was reported by Brophy and Furman who found that the thermal stresses that resulted from cycling from 1800 F to lower temperatures accelerated creep in 25% chrominum–20% nickel and 18% chromium–8% nickel stainless steels by as much as 70-fold.

These early studies first called attention to the very damaging effects of slow and intermittent variations in temperature, and they have been followed by numerous detailed investigations of variations in temperature and stress, either singly or in combination. This is a specialized area in itself, and one that cannot be discussed fully here.



5—*Scatter of stress-rupture data is shown for five heats of Inconel X.* *(International Nickel Co. data)*

Avoid metallurgical change—If extreme variations are avoided and the conditions of stress and temperature do not cause gross metallurgical changes, behavior under intermittent loads and temperatures can, in most cases, be reasonably predicted from the corresponding behavior under constant loads and temperatures. If metallurgical changes are involved, however, creep rates and times to rupture can be greatly accelerated and materials can be weakened much more than might be expected from tests run under constant loads and temperatures. Hence, it can be foolish and unsafe to design solely on the basis of reported values for creep-rupture that were probably obtained under constant loads and temperatures.

Scatter of results

It is common knowledge that a wide variation in creep and rupture behavior exists in specimens taken from different bars of the same heat of an alloy, or even in specimens taken at different positions from the same bar.

Fig 5 shows stress-rupture data for five heats of Inconel X and illustrates the scatter commonly encountered. Minimum creep rates that vary by as much as 50% are considered to be in good agreement for some materials. This is true even for specimens taken from the same length of bar stock.

Numerous tests must therefore be made on as many different specimens as possible from different heats of the same material specification in order to establish a reliable average or minimum value for the particular alloy. Generous safety factors, together with their attendant weight penalty, are the inevitable consequences of wide scatter.

The scatter in creep-rupture results emphasizes the need for controlling the condition of the material, and the wide divergence in properties that results when such control is not exercised.

Scatter of the creep-rupture values obtained on specimens taken from rolled bars and forgings of two heat resisting steels has been studied by Zschokke. The extensive scatter of the results was divided into two groups:

1. That attributed to experimental errors caused by faults in loading or temperature measurement.

2. That attributed to material variations in one and the same workpiece or to differences in separately produced workpieces of the same material.

Variation in one heat

In the first set of experiments, 12 specimens were taken from a single rod of austenitic steel (0.10% carbon, 17% chromium, 13% nickel, 3% tungsten, 0.6% titanium). Two series of six specimens were tested at 1200 F and stresses of 34,800 and 42,600 psi. The average rupture times were 596 and 201 hr, respectively, and the observed ranges were from 527 to 612 and from 171 to 232 hr, which were well within the variation that might be attributed to experimental errors.

In a second investigation of the differences in one piece, Zschokke cut specimens axially from the center and near the surface of an 8-in. dia forged shaft of a heat treated molybdenum-vanadium ferritic steel. At 68 F, there was a large difference between the yield points and impact strengths of specimens taken from the center of the shaft and those taken near the surface. These differences were caused by nonuniform hardening through the cross section. Creep-rupture tests at 570, 1020 and 1110 F showed that in all cases the specimens cut from the surface layer of the shaft had longer lives than those cut from the center, and that the differences were larger than could be accounted for by experimental errors. Zschokke concluded that in rolled bar the material differences in the same bar are less than the experimental error; in forgings the material differences in the same forging are greater than the experimental error.

. . . and in many heats

To study differences between individual workpieces of the same type of steel, Zschokke ran rupture tests on specimens from 38 different forgings of the same molybdenum-vanadium steel considered above. The workpieces weighed between 110 and 5500 lb and included shaft stubs, disks, drums, shafts and swage forgings made by three different steelworks. Each piece was usually from a different melt, but all were ordered to the same specification analysis and material properties. The rupture life at 53,800 psi and 1020 F for these forgings of nominally identical steel varied between approximately 1 and 600 hr.

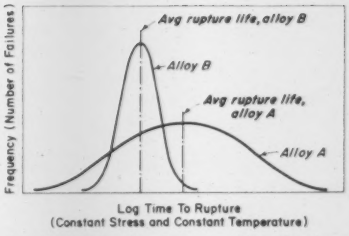
A similar investigation was made of the scatter occurring between test results for rolled bars of the austenitic steel described previously. Sixty-eight rolled bars were taken from 27 batches supplied by five different steelworks. All the bars had been ordered to the same specification and their analyses, with few exceptions, differed very little. The agreement between their mechanical properties, which had also been specified, was less favorable. At 68 F the yield points varied between 61,400 and 103,000 psi, the ultimate strengths between 91,000 and 117,000 psi, the elongations between 23 and 40%, the reduction of area between 44 and 63.5%, and the impact values between 66 and 202 ft-lb. The rupture times at 1202 F differed by factors ranging between 500 and 1000.

These two studies clearly showed that different workpieces of the same nominal material can have wide differences in their resistance to creep and rupture.

Statistical analysis helps

While the metallurgist is primarily interested in the maximum or average properties developed by a new alloy, new heat treatment, etc., the important data to a designer are the minimum values that can be safely relied upon. Often as much can be gained by reducing the scatter as by increasing the general strength level of an alloy. For example, Fig 6 shows the scatter bands for two hypothetical alloys, *A* and *B*. Alloy *A* has a higher average rupture life, as indicated by the peak in the curve, but shows considerable scatter; alloy *B* has a lower average rupture life but less scatter. Since the minimum rupture life that can be guaranteed in alloy *B* is higher than that in alloy *A*, alloy *B* would have a higher design stress.

Two ways are open for obtaining greater design strength in these materials: the first, which may be difficult and expensive, is to increase the strength level of alloy *B*; the second, which might be easily gained by proper attention to the production or fabrication techniques, is to reduce the scatter in alloy *A*.



6—*Possible frequency distributions of the rupture strengths of two high temperature alloys.*

Satistical analysis is being used more and more in an effort to study the problem of scatter in high temperature strength. A statistical study of the creep-rupture behavior of 1100 aluminum at 900 F shows that the variation in rupture life, elongation and reduction of area in bars from a single heat of material may be larger than is generally appreciated. The scatter of log of time to fracture at a given stress was almost normally distributed, and the average lives and the 95% confidence limits ($\pm 2\sigma$) at the various stresses were:

Stress, psi	Average Rupture Life, hr	95% Confidence Limits, hr
450	61.78	33.03–115.57
520	34.60	16.10– 73.93
588	17.45	6.05– 50.33
725	0.78	0.40– 1.52
800	0.54	0.27– 1.08
1100	0.04	0.02– 0.07

Other materials, or 1100 aluminum at a different temperature or in a different heat treated condition, might show more or less scatter than that indicated here.

The three types of high temperature alloys: how structure affects creep-rupture

On a metallurgical basis, alloys used in a creep-rupture environments can be discussed in general terms. Alloying and heat treatment affect the metallurgical structure, and all three factors are related to strength of a material at elevated temperature. This section will discuss the general types of high temperature alloys, why they are effective, and which structure performs best under given conditions.

Solid solution alloys

Solid solution alloys are those in which alloy additions (or impurities) are fully dissolved in the matrix of the parent material. For small concentrations, the addition of soluble

alloying elements generally improves the creep-rupture strength. At large concentrations, however, complications sometimes arise, i.e., the solution of one metal in another is often accompanied by a depression of the melting point. This depression can be abrupt: in tungsten, adding less than 1% iron decreases the melting point from 6170 F to 2985 F. In such cases, the decrease in the melting temperature and the increase in atomic mobility can outweigh the strengthening effect of lattice strains caused by alloying, the net result being a loss in creep-rupture strength. The creep resistance of a solid solution alloy may therefore be a maximum at a particular concentration of solute, and this optimum concentration may change with the temperature and duration of testing.

As might be expected, elements that retard recovery and recrystallization during creep-rupture are most effective in maintaining or improving creep strength. At all temperatures high enough to cause rapid recovery, the effect of alloying additions of soluble elements on creep-rupture strength is small. These general conclusions are based on a number of experiments and materials, of which the early study of Austin, St. John, and Lindsay is a good example. Their results are shown in Fig 7.

The curves in Fig 7 show the effect of increasing concentrations of chromium, cobalt, nickel, manganese, molybdenum and silicon on the stress required to cause a creep rate of 0.1% per 1000 hr at 800 F in ferrite. The strengthening effect was greatest for molybdenum and chromium, intermediate for manganese and silicon, and almost absent for cobalt and nickel.

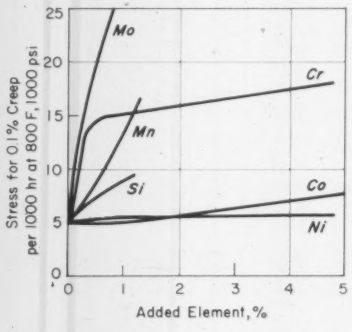
The same order of strengthening was observed at 1000 F, but the effects of silicon as well as cobalt and nickel were negligible, and manganese and chromium gave only slightly improved creep strength. Molybdenum was again the most effective strengthener.

The order of merit for increasing room temperature tensile strength was: chromium, cobalt, nickel, manganese, molybdenum and silicon.

There was no correlation between the relative effect of solute elements on creep-rupture strength at elevated temperature. There was, however, a direct correlation with the effect of these elements on the recrystallization temperature. Nickel and cobalt in solid solution had little effect on this temperature; silicon raised it slightly; and chromium, manganese and molybdenum had softening temperatures well above 1000 F after cold working, and they were the only ones that retained any measure of creep strength at that temperature.

Strength is not the only consideration—In practice alloying elements are added for many reasons other than strength. The most important reason for adding chromium to steel is to improve oxidation and corrosion resistance, and this more than justifies its use in concentrations that are large enough to exert a weakening action. Nickel is often added to insure an austenitic structure as in the austenitic stainless steels, and titanium is added to the austenitic stainless steels as a carbide stabilizer to prevent intergranular corrosion. Molybdenum is added to 5% chromium ferritic steels to eliminate temper brittleness. Thus, there are a large number of important considerations other than strength in selecting an alloy composition.

As the number of constituents increases, certain fabrication difficulties may also increase. For example, welding ferritic steels becomes more difficult, since additions of chromium and other elements make them air-hardenable so that brittle martensitic zones are formed in weld areas. Some of the highly-alloyed ferritic "superalloys" are difficult to weld without cracking, and forgings must be cooled slowly. If there is any general rule for avoiding these difficulties, it is to use the simplest alloy that has the required properties. This alloy usually has the added advantage of being the least expensive.



7—*Effect of alloying elements on the stress required to cause a secondary creep rate of 0.1% in 1000 hr at 800 F in binary solutions of ferrite.*

Steel: vary miscrostructure to suit conditions

The martensitic reaction in steels results in a metallurgical structure that is strong but brittle. Internal strains are high and the structure is unstable. Tempering occurs at relatively low temperatures, permitting partial relaxation of internal strains.

Whether or not tempered martensite is a strong structure for elevated temperature applications depends upon its stability, much as the effectiveness of strain hardening depends upon the stability of a cold worked structure. In both cases strengthening is caused by internal strains in an unstable structure, and the strengthening action is effective only as long as the combination of temperature and service life do not permit significant relaxation of the internal strains and conversion to a more stable structure.

Tempered martensite, which usually offers the best combination of strength and ductility at room temperatures, should be used for extended service only at temperatures below 1000 F. As the temperature increases to 1000 F, the time for which martensite can be used decreases.

Normalize for high temperature service—For extended service at high temperatures, normalizing is generally recommended as a heat treatment for plain carbon and many low alloy steels. To normalize, the steel is heated above its transformation range to form austenite and then cooled in air at an intermediate rate. The rate of cooling is too slow to form martensite but is much more rapid than the slow furnace cool required for annealing. As normalized, the structure is fine pearlite or bainite, depending upon the section size, carbon content, alloying content, etc. A normalized structure is neither as hard and strong as a martensitic one nor as soft and ductile as an annealed one.

Avoid spheroidization—At temperatures slightly below the transformation temperature range, fine particles or plates of carbides coalesce into spheres, reducing creep-rupture strength. In plain carbon and carbon-molybdenum steels, the carbides can break down to form free graphite. Graphitization also weakens the steel, but is easily avoided by proper alloying.

The rate of spheroidization in steels is influenced by many factors. For example:

1. Cold working increases the rate of spheroidization.

2. In general, cast steels are difficult to spheroidize.

3. Since larger carbide lamellae take longer to spheroidize than finer particles, annealed steels have lower spheroidization rates than those which have been normalized or quenched and tempered, and are thus preferable for extreme conditions.

4. Creep strain itself can accelerate spheroidization, so that spheroidization occurs more rapidly under the combined effects of stress and temperature than because of the effects of temperature alone.

Since spheroidized steel has low creep-rupture strength, elements such as aluminum and silicon that promote spheroidization and graphitization in plain carbon steels should be minimized, or alloying elements added to form stable carbides. The effectiveness of many alloying elements in high temperature steels is directly related to the stability of the carbides they form. Strong carbide-forming elements such as vanadium are added primarily because the fine distribution of carbides formed by heat treatment can be retained to higher temperatures without the carbides breaking down and losing their strengthening action.

Bainite offers high strength—Freeman, *et al*, evaluated four ferritic steels (nominal compositions are listed in Table 1) for service as turbine wheels in turbojet engines.

TABLE 1—COMPOSITION OF FOUR FERRITIC STEELS (%)

Steel ↓	C	Mn	Si	Cr	Ni	Mo	W	V
1	0.40	0.70	0.30	0.80	1.80	0.25	—	—
2	0.30	0.55	0.65	1.25	—	0.50	—	0.25
3	0.25	0.40	0.40	3.0	—	0.50	0.50	0.75
4	0.22	1.00[a]	1.00[a]	13.0	0.75	1.00	1.00	0.30

[a]Maximum.

The steels were heat treated by normalizing and tempering, by oil quenching and tempering, and by interrupted quenching to give microstructures varying from martensite through the bainites to coarse pearlites. All four steels had similar creep-rupture strengths for short times and low temperatures—up to about 20 hr at 1000 F and to 1 hr at 1100 F. For longer times at these temperatures and for all times at 1200 F, Steel *1* was weaker than the other alloys. Steel *2* maintained rupture strengths higher than or equal to the best of the other steels for times to 1000 hr at 1000 F. At 1100 F, Steels *2*, *3* and *4* all had about equal creep-rupture strengths, except that Steel *2* was somewhat weaker at times longer than 100 hr. Steel *3* was substantially stronger than the others at 1200 F.

To harden a steel to 300 Bhn, the usual hardness for turbine wheels, a bainitic or martensitic structure is required after heat treatment. One exception: vanadium-bearing steels can reach this hardness level in the lower part of the pearlitic region. In analyzing the creep-rupture strength of these structures, Freeman and his associates made the following observations:

1. Heat treatment to produce bainite gave, on an average, maximum or near maximum strengths at temperatures from 700 to 1200 F for times ranging from 100 to 1000 hr.

2. Within the generalization that bainite produces the highest strength, there was considerable variation. For example, the structure for maximum strength in Steel *1* progressed from lower to middle to upper bainite with increasing test temperature. What is perhaps most important is that one of the bainites, for all temperatures, generally had considerably lower strength. Thus, there is a strong incentive for precisely controlling the structure for an intended service temperature.

3. In normalizing to produce a high level of properties, the cooling rate should be controlled so that the major part of the transformation occurs in the bainitic region. A predominance of martensite or pearlite, because of section size and transformation characteristics, could give inferior properties.

4. Strength of the martensite fell off more rapidly as temperature increased than did the strength of the other structures. However, at most temperatures, martensite outranked at least one of the bainitic structures.

Coarse pearlite preferred—Where hardnesses lower than 300 Bhn were allowed, the softer pearlitic structures offered some advantages. Although pearlitic structures were comparatively weak at the low temperatures, relatively coarse pearlite was preferable for higher temperatures.

Precipitation hardened alloys

With the exception of ferritic steels, which can be strengthened both by the martensitic transformation and by eutectoid decomposition, most of the heat treatable alloys used at high temperatures are of the precipitation hardening type. During heat treatment of these alloys a controlled dispersion of microscopic or submicroscopic particles is formed. Final properties depend on the manner in which the particles are dispersed, their size, and their stability. Because they retain their strength at temperatures above those at which martensite becomes unstable, precipitation hardening alloys are an important class of high temperature materials.

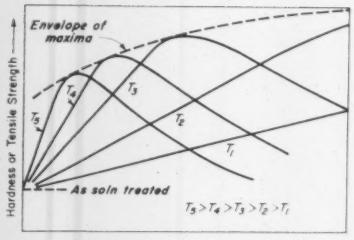
Why precipitation hardening works—If hardening is to result from precipitation, then according to modern theories, some degree of coherency must exist between the crystalline lattices of the precipitate and matrix. If there is a pair of planes—one in the matrix, the other in the precipitate—on which the configuration of atoms is similar, the crystals of precipitate will begin to form with such a plane in registry with a similar plane in the matrix. Differences in atomic spacings will set up "coherency stresses" across this

transition surface. Hardening is not due to a physical "keying" action exerted by the particles of precipitate, but rather to the fields of coherency stresses that surround them.

Distribution of precipitate is important—Precipitation from solid solution, like the eutectoid decomposition in steel, involves the nucleation of a new phase and the subsequent growth of the nuclei. Accordingly, the final microstructure varies with the conditions of precipitation. At high temperatures, where the rate of nucleation of stable particles is low and their growth is rapid, aging produces a coarse dispersion of precipitate. At low temperatures, where the nucleating forces are larger but growth is slow, aging produces a fine dispersion of precipitate. Inhomogeneities within the crystalline matrix, such as grain boundaries, inclusions and undissolved particles, can furnish preferential sites for nucleation.

For service at elevated temperatures, much depends upon the stability of the precipitated particles. Although finer particles exert a greater hardening and strengthening effect than coarse ones, they are not so stable. As a result, the finer particles can over-age and lose their strengthening action in shorter times at elevated temperatures. For prolonged service at elevated temperatures, therefore, the initially greater strengthening action but poorer stability of the finer precipitates must be compromised with the initally weaker strengthening action but better stability of the coarser particles. In other words, unlike short-time tensile strength and hardness, the creep-rupture strength of an alloy does not necessarily show a maximum corresponding to the condition of optimum precipitation hardening. It will do so only when the service temperature is low enough and the time short enough so that no appreciable over-aging occurs during service. For service at higher temperatures or longer times, the condition for maximum creep-rupture strength will vary with the service conditions.

Consider double aging — Since precipitation is a process of both nucleation and growth, greater control can sometimes be exercised over the precipitate pattern by carrying out the aging reaction at several



8—*Typical age hardening curves for an alloy undergoing precipitation (five different temperatures).*

temperatures. A low aging temperature (following solution treatment) favors a fine dispersion and maximum possible hardening, but the rate of precipitation is usually so low that a higher aging temperature must be used in order to obtain significant hardening in a reasonable period of time. You can avoid being forced into this compromise by first aging at a low temperature to obtain a fine dispersion of nucleation sites, and then aging at a higher temperature where growth on the nucleation sites is more rapid. The result is a very fine dispersion of precipitate, typical of very extended aging near the lower temperature.

Use of double aging is limited, of course, to those conditions where very fine dispersions are stable and have the most desirable properties. It was first suggested for wrought HS-21 alloy, a cobalt-base material hardened by the precipitation of complex carbides. The finest dispersion of carbide particles, and the highest creep strength at 1500 F, was obtained by double aging after solution treatment—first at 1200 F to cause scattered nucleation and then at 1500 F to complete the precipitation.

Properties change during aging—During aging, certain properties change. Electrical conductivity generally increases, although deviations from this behavior are found in some alloys. Magnetic properties are also improved. Mechanical properties such as strength, ductility and hardness also vary during the course of precipitation; they are most easily followed by hardness measurements on samples withdrawn after various times and temperatures of aging. Increases in hardness generally mean an increase in strength and a decrease in ductility, and vice versa.

Fig 8 shows schematically a set of typical age hardening curves for an alloy undergoing precipitation. At a low aging temperature, T_1, the rate of precipitation, and consequently the rate of hardening, is slow. At a slightly higher temperature, T_2, the atoms are more mobile and precipitate from the supersaturated solid solution more rapidly; accordingly, the rate of hardening is more rapid than at T_1. At a still higher temperature of aging, T_3, hardness reaches a maximum value and then drops off; this hardness decrease is known as overaging. The maximum hardness possible generally decreases as aging temperature increases. The optimum hardness, i.e., the highest hardness that can be reached in a reasonable aging time, will be somewhat less than this maximum. Overaging occurs sooner as the aging temperature is raised (e.g., temperatures T_4 and T_5).

Dispersion hardened alloys

Dispersion hardening refers to strengthening an alloy by introducing into it a fine dispersion of stable particles by methods other than heat treatment. Although in some respects it is similar to precipitation hardening, it differs in the types of secondary phases employed, the means for dispersing them, and probably in the mechanism of strengthing. In the case of precipitation hardening alloys, there is an upper limit to the times and temperatures at which the precipitated particles are stable and can exert their strengthening action. This follows essentially from the fact that in order to be capable of heat treatment, the secondary phases must dissolve into the matrix at some temperature below the melting point of the alloy. In dispersion hardened alloys, however, it is preferable that the secondary phase be almost completely insoluble all the way up to—and even above—the melting point of the matrix. Therefore, it must be dispersed by some means other than heat treatment. Once the second phase has been dispersed it is more stable and retains its strengthening action to higher temperatures than are possible with conventional precipitation hardening alloys.

Dispersion hardening mechanism

not well understood—The mechanism of dispersion hardening is not yet well understood. There is no evidence available at present to indicate that coherency stresses, such as are responsible for precipitation hardening, exist in the metal-oxide or other dispersion hardening systems. It is possible, of course, that thermally induced stresses and strains may be developed in the matrix surrounding refractory particles as a result of unequal rates of expansion and contraction during the various stages of processing, and that strains may also arise through interfacial free energy relationships or surface tension. Such strain fields should act as dislocation traps for impeding plastic deformation, much as do the strain fields caused by coherency stresses. Also, since the role of grain boundaries becomes increasingly important at elevated temperatures, some consideration must be given to the effect of the dispersed phase in strengthening and immobilizing grain boundaries. Theories of dispersion hardening have been reviewed in an excellent paper by Grant and Preston.

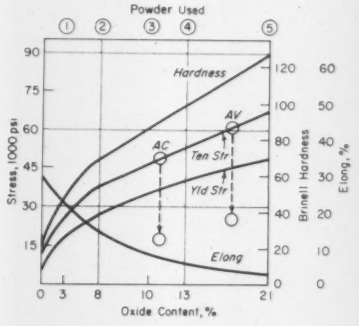
Four types of alloys—In general, there are four types of dispersion hardened alloys. The difference between them depends on how the dispersed refractory phase is introduced into the matrix.

1. SAP—Attention has recently been directed to dispersion hardened alloys by the phenomenal high temperature strengths achieved by the SAP process for producing sintered aluminum products containing dispersed aluminum oxide, a process which has been under development in Switzerland since 1946. The process uses aluminum flakes that are about 1μ or less in thickness and have an oxide layer on the order of 0.01μ. Compression and sintering of these flakes are followed by extrusion at 930 to 1110 F.

Fig 9 shows the variation in 0.2% yield strength, ultimate tensile strength, hardness and ductility of extruded sintered compacts prepared from different grades of aluminum powder. Powders *1* to *5* are in the order of decreasing particle size and increasing oxygen content; powder *1* is the coarsest and powder *5* the finest. When no oxide is present, the properties are similar to those of annealed aluminum. The ultimate tensile strengths of two heat treated aluminum alloys, Anticorodal (an aluminum - silicon - magnesium alloy, denoted AC) and Avional (an aluminum-copper-magnesium alloy, denoted AV), are indicated for comparison. SAP alloys with more than 10% oxide are stronger than either of the two heat treated alloys, but have less ductility. Most important is the retention of strength by the SAP alloys when heated. Prolonged heating for several months at 930 F had practically no effect on properties of the SAP alloys, while heating for only a few hours at 750 F reduced the ultimate tensile strengths of the two heat treated alloys to the values indicated by the arrows in Fig 9.

The properties of SAP cannot be obtained from mixtures of aluminum and aluminum oxide powders. The oxide must be formed as a surface film during manufacture. The plasticity of the aluminum particles enables them to be deformed so that the oxide films are broken and the particles weld together during pressing, sintering and extrusion.

Numerous attempts have been made to duplicate the SAP type of product with other metals, but as yet this particular process has been successful only with aluminum and, perhaps, magnesium. Attempts with titanium have been unsuccessful because the oxide tends to dissolve readily into the matrix at relatively low temperatures. In the case of copper, the cuprous oxide is plastic and tends to spheroidize and coagulate. Other methods for dispersing the refractory particles are therefore under study.



9—*Influence of oxide content and particle size on the strength of sintered aluminum compacts (SAP) at room temperature. Particle size decreases as alloy content increases; powder 1 is coarsest and 5 is finest.*

2. Mechanical dispersions—The most direct method for dispersing a refractory phase appears to be simple mechanical mixing of refractory and metal powders by ball milling them together in the desired proportions, followed by compacting, sintering and extruding. Two of the main problems are obtaining fine powders to begin with and preventing segregation during processing. Fine powders of both the metal and refractory compound must be used; otherwise the spacing between the refractory particles is too great for effective strengthening.

3. Internal oxidation — Internal oxidation can be used to produce fine dispersions in a noble metal that contains a small amount of a second element which has a high affinity for oxygen. Under the proper conditions, oxygen diffuses into the alloy to precipitate small particles of the oxide of the solute metal dispersed in the alloy matrix.

4. Atomized powders — Towner has described a method for dispersing intermetallic compounds of aluminum in an aluminum-rich matrix by using atomized alloy powders. In the atomizing operation very small molten particles, about 25μ in dia, were quenched in the surrounding atmosphere. Because of the high rate of solidification, the powder particles had an extremely fine dendritic structure and, therefore, a fine distribution of the intermetallic. Fabrication by compacting and extruding broke up the cast structure and further increased the fineness of dispersion. Elements such as iron, chromium and nickel were beneficial because they form stable intermetallic compounds with aluminum, such as $FeAl_3$, that have fairly low densities and are relatively insoluble in aluminum. About 7 to 12% of the alloying element, or elements, was needed to produce alloys that compared favorably with other high temperature aluminum alloys.

Refractory compounds not always needed—It is rather surprising, perhaps, that the precipitated particles need not be hard, refractory compounds. Voids have also been observed to raise the recrystallization temperature, hinder grain boundary

movement, and increase high temperature strength. Middleton, *et al*, attributed the marked increase in the recrystallization temperature of platinum wires produced by powder metallurgy as compared to that of conventionally cast and wrought metal to the presence of a small amount of suitably dispersed porosity. He also reported higher creep-rupture strength for the powder product.

Effects of heat treatment and cold work

We have discussed, in a general way, the types of alloys which are specified for high temperature applications. The type of metallurgical structure to specify has also been discussed. Other factors, as important in their way as the choice of material, must also be considered. These are the metallurgical factors which, if not controlled or properly applied, can make a chosen material unfit for service.

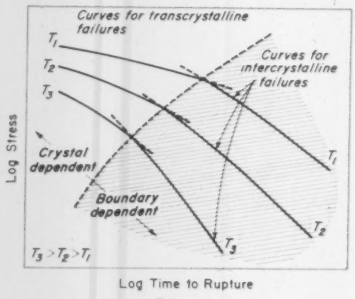
Knowing the effect of various metallurgical factors on creep-rupture behavior is important in understanding both how optimum properties are obtained and why controls are needed to insure reliability in those properties. Although specific materials will be used to illustrate the effects of the various metallurgical factors, emphasis is on the principles involved.

Grain boundary and grain size effects

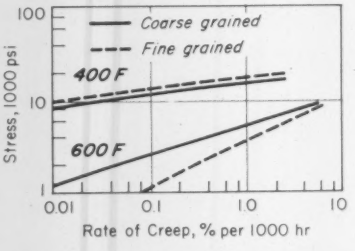
Equicohesive temperature — At room temperature the path of fracture through most metals is transcrystalline—through the grains. At high temperatures fracture is intercrystalline and follows the grain boundaries. At some intermediate temperatures the fracture path is both through the grains and along the grain boundaries. This temperature, at which the grain boundary material and the crystalline metal appear to be equally strong, is called the "equicohesive temperature."

Actually, the equicohesive temperature is not constant for a material but varies with the stress (or the strain rate) and time to failure. At a given temperature, a material may fail under a high stress (high strain rate) in a transcrystalline manner or under a low stress (low strain rate) in an intercrystalline manner. This leads to the interpretation that the conventional logarithmic curves of stress vs time-to-rupture consist of two separate branches, as shown in Fig 10, corresponding to the stress-rupture properties of the matrix and the grain boundary material. There is some controversy regarding the existence of a sharp point where the two branches of the curve meet, and in practice the entire range of behavior is usually represented with equal accuracy by a single smooth curve.

Grain size—The concept of equicohesive temperature leads naturally to a consideration of grain size. Fine-grained material has a greater relative amount of grain boundary area than coarse-grained material. Thus, it should be stronger at low temperatures and high stress, and thus show transcrystalline failures. Conversely, coarse-grained materials should be stronger at high temperatures and low stresses, where failure is by intercrystalline cracking. Experimental studies generally support these conclusions, provided that other factors do not enter and mask the effects of grain size. This qualification is important; many contradictory statements have been made on grain-size effects because of the difficulty of eliminating side effects that accompany the methods used to vary grain size.



10—*Equicohesive temperature is plotted (dashed line) along boundary of crystal-dependent and grain boundary-dependent failures.*



11—*Effect of grain size on creep rate of copper-zinc-tin alloys. As temperature increases, strength of coarse-grained specimens increases.*

Fig 11 shows some results of an early study of the effect of grain size on the creep strength of a copper-tin-zinc alloy. The coarse-grained specimen was stronger at the higher test temperature and the fine-grained specimen was stronger at the lower test temperature.

Controlling grain size—Several ways are available for controlling grain size. In cast materials, grain size can be varied by changing the metal pouring temperature and the mold preheat temperature. Generally, the metal pouring temperature has the predominance effect; grain size increases as pouring temperature increases. The highest pouring temperature is limited by mold deterioration and resultant poor surface, and the lowest pouring temperature is limited by the ability of the metal to fill the mold completely and produce a sound, dimensionally correct casting. Coring, interdendritic segregation, distribution of secondary phases, deoxidation practice and orientation effects may mask the effects of grain size.

In wrought materials grain size can be controlled by cold working followed by recrystallization and the desired degree of grain growth at the proper temperature. This method of grain size control is commercially feasible for alloys that strain harden readily, such as austenitic steels. A high austenitizing or normalizing temperature favors large grain size in ferritic steels. In many cases, however, an increase in strength with increased grain size can be at-

tributed to other microstructural changes induced by the heat treatment used for grain coarsening. Thus, precipitation of minor phases can occur during creep, particularly if the annealing temperature is high enough to dissolve some of the constituents of the cold worked metal. The manner and rate of precipitation will be influenced by the degree of solution during annealing and by the final grain size, so that the strength and ductility of specimens of different grain sizes may not vary in the manner expected from the variation in grain size alone. Also, the creep resistance of a number of materials appears to be insensitive to grain size.

Although high temperature creep-rupture strength is often favored by large grain size, other conditions encountered in service may be aggravated by large grains. For example, alternating or vibratory stresses are generally thought to be withstood better by fine-grained material than by coarse-grained, although the existing data on the effect of grain size on high temperature fatigue strength are not conclusive. Depending upon the service conditions, one must therefore balance the advantages and disadvantages of different grain sizes in order to arrive at an optimum condition.

Annealing

When a strained or deformed metal is heated at a sufficiently high temperature, it undergoes a sequence of changes that tend to restore it to near-perfect crystallinity. This process is known as annealing, and the changes take place in three more or less distinct stages known as recovery, recrystallization and grain growth.

Ordinarily, annealing is performed to soften a metal when the hardness and brittleness of the strain hardened metal is not desirable. When strain hardening caused by cold working is severe, the metal must be annealed several times between stages to prevent its becoming too hard and brittle to deform without cracking. In some high temperature applications, annealing occurs during service, removing the strengthening action of strain hardening, whether such hardening has been introduced by prior cold work or by creep deformation itself. Thus, the secondary stage, or constant rate, of creep has been explained as a running balance between strengthening the material by strain hardening and weakening by annealing, so that the condition of the material and its creep resistance stays constant.

TABLE 2—
MINIMUM RECRYSTALLIZATION AND MELTING TEMPERATURES

Metal ↓	Min Recryst Temp, F	Melting Point, F
Tungsten	2192	6170
Tantalum	1832	5425
Molybdenum	1652	4757
Nickel	1112	2651
Iron	842	2802
Platinum	842	3225
Gold	392	1945
Silver	392	1760
Copper	392	1985
Aluminum	302	1220
Magnesium	302	1202
Zinc	Room temp	788
Cadmium	About room temp	610
Lead	Below room temp	621
Tin	Below room temp	450

Recrystallization

Recrystallization is the portion of the annealing process in which strain-free grains form from the strained matrix, and it is marked by a pronounced drop in hardness. The minimum temperature of recrystallization is determined in practice as the lowest temperature at which a severely deformed specimen shows definite softening after a prolonged period of heating. In general, as melting point of a metal increases, minimum temperature of recrystallization also increases, as shown in Table 2.

Cold working is defined as plastic deformation of a metal *below* its minimum recrystallization temperature; hot working as plastic deformation *above* the minimum recrystallization temperature. Lead can be *hot* worked by deforming it at room temperature; tungsten can be *cold* worked at temperatures close to 2200 F.

The significance of recrystallization temperature, so far as the use of a metal at elevated temperatures is concerned, is that it marks a limit above which internal strains, such as those produced by plastic deformation, no longer exert a strengthening action. For extremely high temperatures, metals with the highest melting points should be used because they have the highest recrystallization temperatures.

Increase recrystallization temperature, increase strength—One of the first methods for increasing the creep-rupture strength of a pure metal is to do something, such as alloying, that will raise its recrystallization temperature. Experiments show that the temperature and rate of recrystallization of a metal are considerably influenced by impurities and alloying additions. Additions on the order of 0.01% of manganese and iron are reported to decrease the rate of recrystallization of high purity aluminum by factors of 10^{12} and 10^{16}, respectively, a surprisingly large effect for such small additions. For alloying additions made substitutionally, the increase in recrystallization temperature appears to be governed principally by the difference in atomic diameters of the alloying element and the base metal, although other factors seem to be involved also. All other factors being equal, however, the larger the difference between the atomic diameters of the parent metal and the impurity or alloy addition, the greater the increase in the recrystallization temperature.

Grain growth related to temperature, cold work—The size to which the grains grow during recrystallization depends upon the rate at which nuclei form and the rate at which the grains grow. At the lower temperatures the rate of growth is slow, and many nuclei are formed. Annealing a deformed metal at temperatures just above the minimum recrystallization temperature produces the minimum grain size and is called *grain refining*. At higher temperatures the grains grow faster, and the metal may be entirely recrystallized before many nuclei have had a chance to get started; this produces a coarse grain size. Thus, as a general rule, grain size increases as recrystallization temperature is raised.

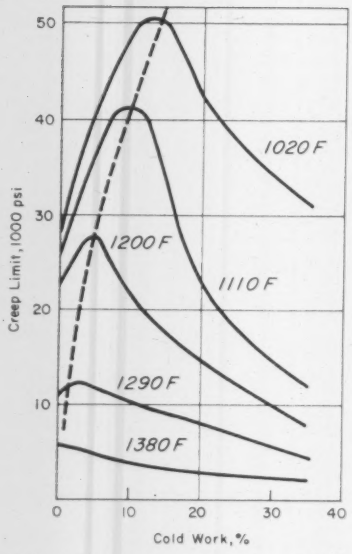
Size of the recrystallized grains also depends upon the amount of prior cold working. If this has been very slight, there is not enough disturbance of the metal to cause many nuclei to form, and the recrystallized grains are abnormally large even at low annealing temperatures. Deliberate use is often made of this

behavior in order to produce specimens with large grains for special tests; the specimen is elongated slightly—say 1%—and then annealed at a high temperature. More often, however, this behavior is a disadvantage. For example, in forging turbine blades of certain high temperature superalloys, some areas of the blades receive very slight amounts of cold working. During subsequent heat treatment at elevated temperatures, these areas germinate large grains that have undesirable mechanical properties, such as poor fatigue strength.

Recrystallization and rupture—Recrystallization often accompanies the acceleration in the rate of deformation during the third stage creep of some materials in which the reduction of area during necking is insufficient to account for the acceleration. Recrystallization has been observed during creep-rupture tests at temperatures several hundred degrees lower than the minimum softening temperature of severely cold worked specimens. In other words, recrystallization seems to occur at lower temperatures or at greatly accelerated rates when straining and annealing occur simultaneously than when they are done separately.

Strain hardening

Strain hardening, or cold working, is one of the most effective means for increasing the strength and hardness of many metals and alloys. For service at low temperatures this procedure presents no difficulties; atomic mobility is too low for any of the processes of annealing to occur and the cold worked structure is mechanically stable. When a cold worked part is to be used at elevated temperatures however, recovery, recrystallization and grain growth can and do occur. The rate and extent of their occurrence in a given material vary with the amount of prior cold work and with the stress, temperature and time of creep. The amount of strengthening to expect at elevated temperatures from prior cold working depends on factors other than simply the amount of cold working. Since cold working introduces strain energies which accelerate the atomic rearrangements of annealing, cold working can actually weaken a material at elevated temperatures.



12—*Cold work affects creep limit of an austenitic steel. Effect is reduced as temperature increases.*

Optimum amount of cold work—The fact that there is an optimum amount of prior cold work is demonstrated by experiments on an austenitic steel reported by Zschokke and Niehus. Their results also showed how this optimum varies with the temperature of testing. Creep tests were conducted at 90°F intervals from 1020 to 1380 F on specimens that had been cold worked up to 35%. Fig 12 shows the variation with cold work of the "creep limit," i.e., the stress at which no detectable creep takes place under the particular experimental conditions at each test temperature. From the data:

1. At each test temperature, there is an optimum degree of cold work to produce the highest creep resistance.

2. Effect of cold work is more pronounced at test temperatures than at the higher temperatures. It disappears rapidly as recrystallization temperature is approached. In this case the effect of prior deformation was negligible at 1380 F.

3. The locus of the maxima of the curves for various test temperatures, drawn as a dashed line in Fig 12, shows that the optimum degree of cold work is appreciably larger for low creep test temperatures than for higher temperatures.

The case AISI 347 stainless steel, considered earlier in this article, showed a similar decrease in effectiveness of cold working as test temperature was raised. Effectiveness of cold working also decreased with service life.

These results show that if advantage is to be taken of the effect of cold working to increase the creep-rupture strength, the degree of cold working must be chosen with some care in relation to the particular temperature of operation. Also, if fabricating conditions are not carefully controlled there may be a good deal of scatter in the final properties achieved.

Fundamental studies by Freeman and co-workers have shown that the effects of prior strain on creep-rupture strength are related to the introduction of internal strains in the metal lattice, as revealed by the broadening of x-ray diffraction lines. The optimum amount of strain hardening for improving high temperature strength decreases as either service temperature or life increases. Greater amounts of prior strain promote relaxation of internal stress during service at elevated temperatures and their removal as a strengthening mechanism. For service at very high temperatures or very long times, material in the annealed condition may be stronger than that in the cold worked condition. Finally, prior straining, as in rolling or forging, must be done at temperatures below those at which the internal stresses relax, either during deformation or while cooling after deformation.

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SILICONE NEWS

for design and development engineers • No. 79

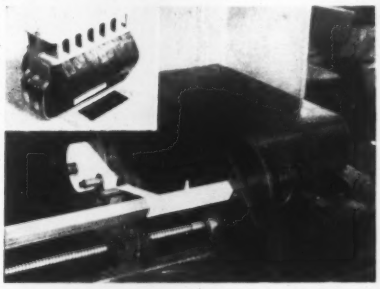
SILICONE RESIN HELPS MEET TOUGH SPECS

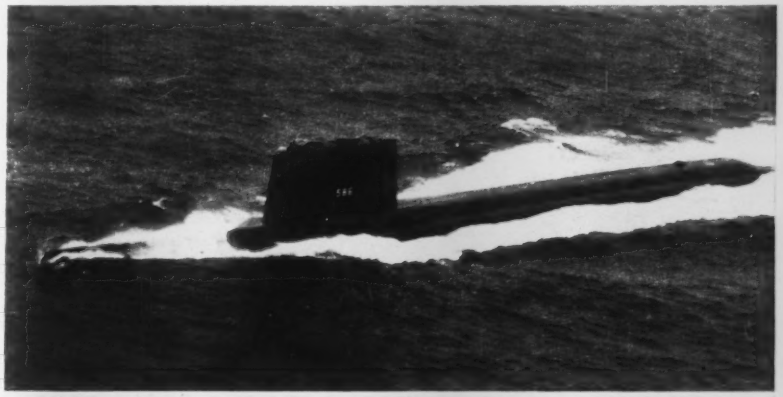
Solventless silicone resin helps meet stringent reliability requirements. Example: transformer start tubes manufactured by Osborne Electronic Corporation, Portland, Oregon.

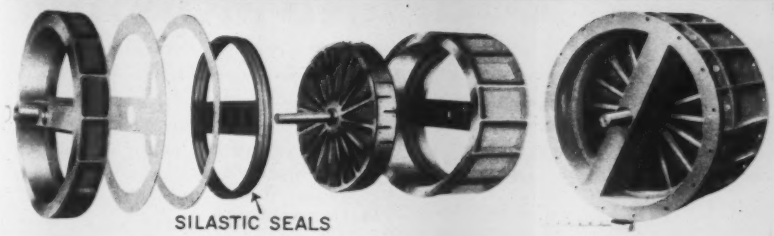
Osborne manufactures specialized high-performance transformers that are virtually standard equipment on major jets, such as the B-52, KC-135 and 707. To produce top quality start tubes of special sizes and shapes, Osborne engineers wrap glass tape on a mandrel, saturate it with Dow Corning solventless silicone resin, and then cure the tube form by heating.

These silicone-glass tubes meet all of Osborne's construction, performance and reliability requirements:

a. Retain mechanical and dielectric strength from —65 to 200 C . . . resist intermittent exposure to 250 C. *(Cont. Pg. 2)*







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Silicone engineering materials often enable you to design "through" rather than "around" a problem. A heat exchanger manufactured by the Air Preheater Corporation, Wellsville, N.Y., provides a fine example.

Air Preheater makes rotary regenerative heat exchangers for atomic submarine air purification systems. When these extremely compact units are in operation, heat of the purified air pre-warms the stale air before it goes to the catalyst bed. Thus, the air entering the system is raised from room temperature to 575 F, and the purified air is cooled from 650 F to 175 F. This procedure, designed to aid efficiency, saves a combined heating and cooling load of about 70 kw.

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The Silastic foam cushion seal remains resilient in high temperature service; withstands compression loading created by rotor expansion; and has good resistance to friction and tearing action of the rotor. According to the designers, much of the success of the preheater can be attributed to the method of sealing. *No. 241*

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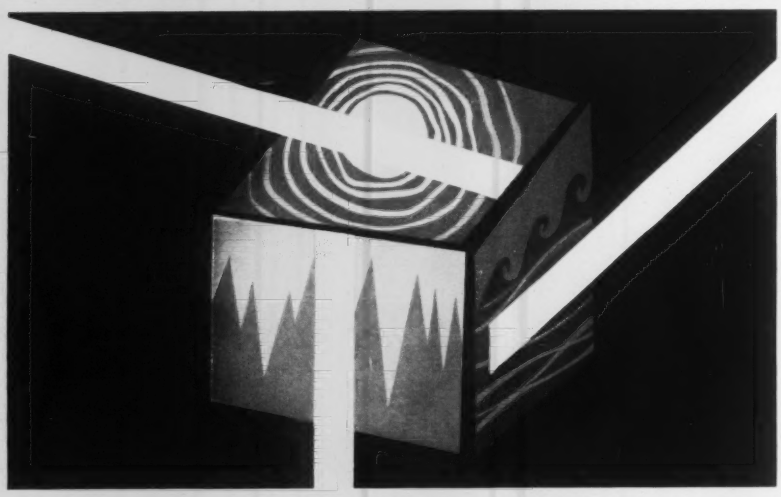

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PRICES & SUPPLY

...AT A GLANCE

Polyester film prices have been cut by Du Pont. Type C Mylar film has been reduced 25¢ per lb in 25 and 35-gage and 15¢ per lb in 75-gage. Type A film has been reduced 20¢ per lb in 50-gage and 25¢ per lb in 300, 500, 750 and 1000-gage. The current reductions, the sixth since start of commercial production in 1954, bring the price of Mylar polyester film in the range of $1.55 to $3.65 per lb.

A new supplier of beryllium metal products is General Astrometals Corp., 320 Yonkers Ave., Yonkers, N. Y. The new company says that much of its activities will center on the production of beryllium metal powder parts for use in aircraft, missiles and other products.

Look for higher prices on silver this year, says Simon D. Strauss, vice president-sales, American Smelting & Refining Co. Mr. Strauss bases his forecast on the likelihood that government stockpiles of silver will be reduced close to the vanishing point in the next 20 months. The government holds the price of silver in check with its stockpile.

A new series of epoxy resins—epoxidized polyolefins—is now in semicommercial production at the Baltimore plant of Food Machinery and Chemical Corp. The resins, designated Oxiron, are being evaluated for use in laminates, castings, adhesives and coatings. The new epoxy resins were described in the Apr '60 issue of this magazine (p 19).

Price reductions on lead and zinc have been announced by the major producers. New price for lead is 11¢ per lb, down 1¢ per lb. Zinc's new price is 12½¢ per lb, down ½¢ per lb. Prices of the two nonferrous metals have remained unchanged for almost a year.

A price cut on styrene-butadiene latex has been announced by Dow Chemical Co. Tank car price is now 27½¢ per lb, a reduction of 2¢ per lb.

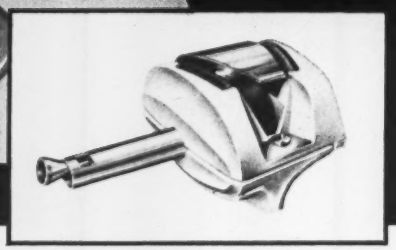
A major new source of molybdenum ore has been located by Molybdenum Corp. of America in New Mexico. The site is said to contain 260 million tons of ore holding about 760 million pounds of metal.

Price of general purpose polystyrene molding compounds has been cut 3¼¢ per lb to 18¼¢ per lb by Monsanto Chemical Co., Foster Grant Co. and Dow Chemical Co. The new price is based on shipments of 20,000 lb and over.

Price cuts on polycarbonate resins have been announced by Mobay Products Co. New truckload price is $1.30 per lb for natural color and $1.50 per lb for pigmented grades. Previous prices were $1.50 per lb for natural and $1.75 per lb for pigmented grades. Another polycarbonate producer, General Electric Co., has also reduced prices on its line of Lexan resins (M/DE, Dec '60, p 25).

A complete roundup of current prices will appear in the March issue.

it beats everything*



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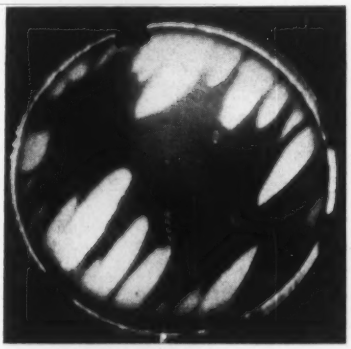
(cont'd from p 88)

Superconductive Domains Shown

Transformations between the normal and superconductive states of materials can be observed visually by a new method developed by scientists at the General Electric Research Laboratory.

The technique is said to be important in investigations of the effects of impurities and metallurgical treatments on metals. Superconductive devices are expected soon to be used in computers and guidance and control systems for missiles and aircraft because electrical resistance and magnetism disappear from metals at absolute zero.



***Thin tantalum sheet** shows the effect of cold rolling on the intermediate state in a superconductor. Normal areas (light) are elongated in the direction of rolling. Superconducting areas are dark.*

Polarized light shows domains

In GE's method, a combination of magnetic and optical effects are used to show the distribution of superconducting and normal domains in a mixture of the two known as the "intermediate state." A strong magnetic field is imposed on the metal specimen held at a temperature slightly above absolute zero to make parts of the specimen superconductive. The thin specimen is placed over the optical part of the apparatus which consists of a cerium phosphate glass disk also located in the magnetic field. When magnetized, the glass rotates the plane of a beam of monochromatic polarized light which is viewed through an adjustable polarizing filter.

Since the superconductive domains are magnetic insulators, they shield portions of the glass from the field. These contrast with the normal areas so the visible pattern corresponds directly with the distribution of superconducting and normal metal in the sample.

Weight Penalty in Supersonic Transports

Heating at supersonic speeds imposes severe restrictions on the construction and design of supersonic transports. E. E. Mathauser of the National Aeronautics and Space

We Made a Mistake on Malleable

The manual, "Guide to Ferrous Castings," published in the Oct '60 issue, pp 127-142, contained several obvious errors concerning malleable iron. Table 11 of the manual (p 134), where it concerns malleable iron, should be changed as follows:

Material	Composition, % Total C	Comb C	Si	Mn	Condn	Temp	Charpy Impact, ft-lb
Malleable Cast Iron	2.65	—	0.90	0.55	Heat treated	RT	16.5*

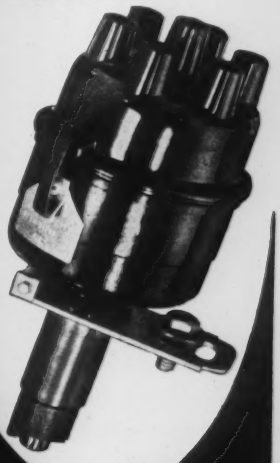
* Impact resistance unaffected to −50 F.

This problem is also discussed in a letter to the editor, p 27.

example...

FIBERITE

Reinforced phenolics at work...



for ELECTRIC AUTOLITE distributor bowls

Electric Autolite of Toledo needed a plastic molding compound for ignition distributors in automotive and industrial engines. The molded part must maintain rigid dimensional tolerances under very adverse conditions of temperature and humidity. Autolite specified Fiberite No. X-2414 cotton fiber reinforced phenolic. Here is Autolite's report:

1 Dimensionally stable
2 Impact resistant
3 Heat resistant
4 Corrosion resistant
5 Light weight
6 Easily machined

EXPLORE FIBERITE

If you need a reliable molding compound with excellent electrical and mechanical properties plus the best in resistance to shock, chemicals and heat, explore Fiberite.

We have formulations to fit a variety of applications. Our research department is at your disposal. Write for the Fiberite catalog.

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Winona, Minnesota

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Machining Bond on Castings

Here's the **MBC** plan: if you uncover a flaw while working on one of our castings, we pay your machining cost. This is in addition to replacing the casting without charge.

Our customers like the **M**achining **B**ond on **C**astings. It is one more assurance that it pays to buy high quality castings in the first place. Please write for our booklet on the Resources and Capabilities of:

Morris Bean & Company
Yellow Springs, Ohio

aluminum and ductile iron castings

BEAN

For more information, circle No. 349

Administration's Langley Research Center has analyzed weight penalties at higher temperatures for aluminum, stainless steel, titanium and beryllium for both conventional skin-stringer construction and sandwich construction.

Aluminum use limited

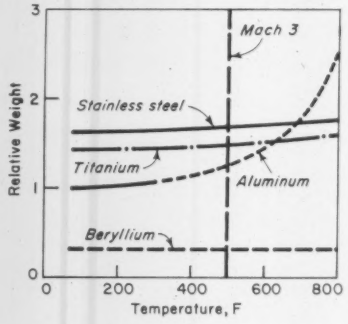
Although the weight of aluminum required in skin-stringer construction is less for operation below approximately 600 F (corresponding to speeds slightly faster than Mach 3) it gains rapidly above 600 F and overtakes both titanium and stainless steel, as shown in Fig 1.

Fig 2 shows that aluminum does not have an initial advantage in sandwich construction, and weight penalty becomes prohibitive below Mach 3.

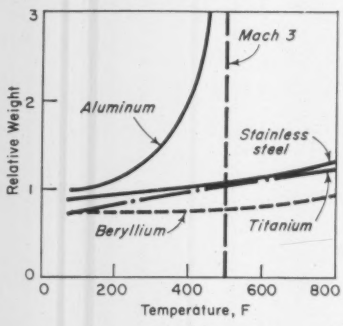
Aluminum also deteriorates steadily with long-time exposure to elevated temperature. For example, after 30,000 hr at 350 F (Mach 2.5), strength has dropped to approxi-

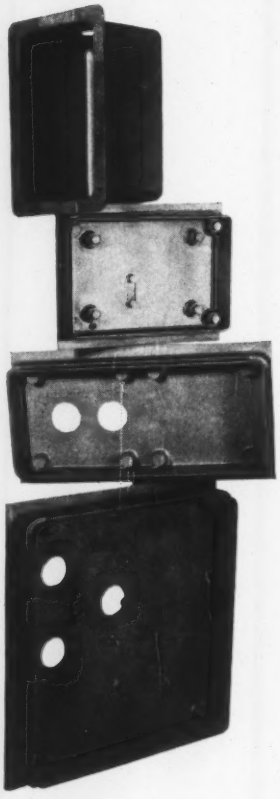
Structural weight comparison for . . .

***1**—Skin-stringer construction*



***2**—Sandwich construction*





Aluminum cans for electronic applications are cast accurate, smooth and pressure tight by the unusual foundry methods of Morris Bean & Company, Yellow Springs 5, Ohio.

BEAN

aluminum
magnesium
ductile iron
foundries

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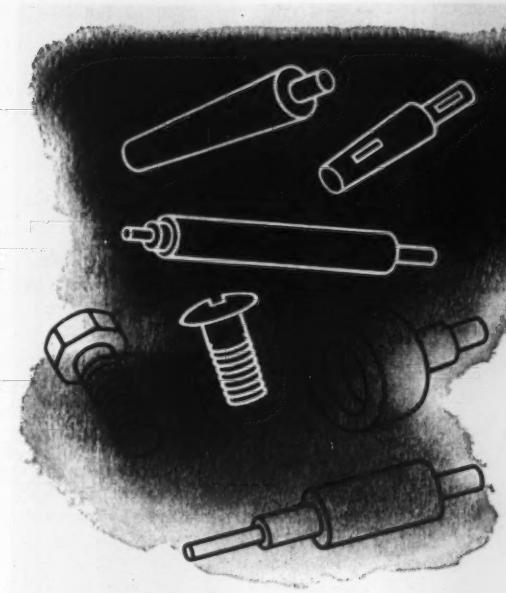

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High Strength Steel

No Further Heat Treatment Necessary!

Here's the high strength steel that cuts engineering and maintenance problems to the bone on maintenance and machine tool applications. Unexcelled strength, good toughness and increased wear resistance—these are the advantages of VISCOUNT 44, even when exposed to temperatures up to 1000°F.

More important, risk of size change and distortion of critically-engineered parts during heat treatment is completely eliminated. VISCOUNT 44 is furnished prehardened at Rockwell C 42-46 . . . it's practical to machine . . . easy to work!

NOMINAL ANALYSIS

Carbon	.40	Chromium	5.00
Silicon	1.00	Molybdenum	1.20
Manganese	.75	Vanadium	1.00

plus Alloy Sulphides

MECHANICAL PROPERTIES

Furnished Hardness	RC 42-46
Tensile Strength	180,000-220,000 psi
Yield Strength (0.2% offset)	160,000-200,000 psi
Reduction of Area	40-50%
Elongation, 2"	10-15%
Coefficient of Expansion 80-1000°F	7.0 x 10^{-6} inches/inch°F

Have a high strength steel problem? Call a Latrobe sales engineer today! Or, send for VISCOUNT 44 literature.

TYPICAL APPLICATIONS

Spindles • Shafts • Brake Dies • Forming Rolls • Tie Rods
Arbors • Axles • Bolts • Structurals • Cams

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LATROBE STEEL COMPANY
LATROBE, PENNSYLVANIA

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the laminate of many uses!

...as a non-metallic structural material—tensile strengths to 30,000 p.s.i.—parts to 13 feet long and 5 inches thick—tailored mechanical properties to fit your needs—machines easily to engineering tolerances.

...as a dielectric—high dielectric strength—low power factor—used by every major heavy electrical equipment manufacturer.

...as a non-metallic fastener—available off the shelf as studs, continuously threaded rods or bolts with matching square or hexagon nuts.

...as a silent gear—special grade gives uniform tooth strength. Diameters to 48", face widths to 4".

...as thermal insulation at very low temperatures—Permali retains most of its mechanical strength at the temperature of liquid gases.

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And Permali, Inc. can design, machine or build your parts or structures regardless of size.

Technical literature on any or all the above applications available on request to

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TWX: MT PL PA 161

For more information, turn to Reader Service card, circle No. 350

mately 53% of the room temperature value.

The weight penalty of both titanium and stainless steel is low in both skin-stringer and sandwich construction. Although beryllium is lighter and has only a slight weight penalty, its scarcity, toxicity and high fabrication costs are against its widespread use.

Stringer or sandwich?

Sandwich construction is, in general, lighter than stringer for low loading levels, sometimes by as much as 25 to 50%. However, the use of sandwiches may be limited for several reasons: 1) cost is considerably higher than for stringer, 2) comparative reliability and serviceability are unknown at present, and 3) full theoretical gain cannot be achieved because of the difficulty of joining pieces.

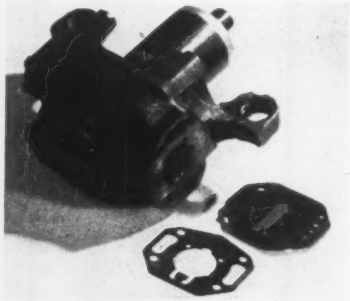
Further details are given in NASA Technical Note D-423, obtainable from National Aeronautics and Space Administration, Washington 25, D. C.

Compressor Uses Precise Gaskets

Asbestos fibers saturated with neoprene are being used for special compressor gaskets with very precise thicknesses and predictable recovery from pressure.

Thickness, recovery critical

In the compressor shown in the photograph, gasket thickness must be controlled very closely. For optimum performance the piston, at the



***Gasket thickness** between this compressor's piston and valve plate is critical.*

This won't stop corrosion—

but versatile-flexible

TYGON® WILL!

Simply crossing the fingers doesn't help much when it comes to corrosion control. But a sure-fire method—and much more economical in the long run—is to specify Tygon if corrosion is a problem in any product you make. Available in a variety of convenient forms and job-specified formulations, Tygon offers superior resistance to a wide range of acids, alkalies, salts, alcohols, oils and solvents.

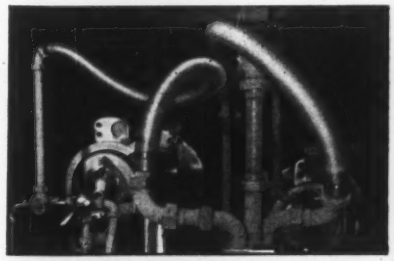
CHECK THE WAYS TYGON CAN IMPROVE VALUE AND PERFORMANCE OF YOUR PRODUCT

AS A COATING

Easily applied by brush, spray, dip or roller-coat, Tygon forms a fast-cure, tough, impermeable plastic barrier that seals out corrosive fumes and acids. Gives equipment longer lasting protection against chemical attack and extreme moisture.

AS LININGS

Tygon Sheeting offers heavy-duty protection against corrosive solutions in storage and processing tanks of all shapes and sizes. Easier to install, handles many of the tough jobs rubber and other linings cannot do.

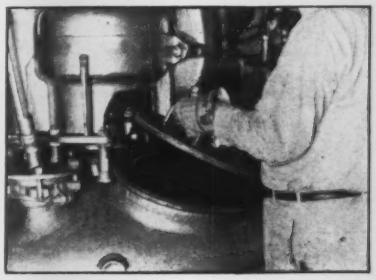


AS TUBING OR HOSE

Flexible, glass-clear Tygon Tubing is ideal for piping flavor-sensitive liquid foods or corrosive chemicals. Non-toxic, non-contaminating, sterilizable. Tough, durable, abrasion-resistant for long service life. Available 1/16" to 4" I.D.

AS GASKETING

Tough, resilient Tygon Gasketing assures tight, durable, leak-proof sealing. Its excellent chemical resistance eliminates costly corrosion "trouble spots" where other materials fail. Cut from sheet, tubing, solid cord, or molded to your specifications.



Write for detailed Tygon Portfolio today—or ask our engineering staff to recommend the proper Tygon formulation for your application.

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

445-F

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AMPCO®

Do you have to

COPE WITH THESE CONDITIONS?

*High heat as compared to other copper-base alloys.

you combat them all with an AMPCO® metal

What does a copper-base alloy have to do for you? Whatever it is, there's a grade of Ampco metal — or other Ampco alloy — that does the job exactly.

Equally important, you can select the best, most economical form of production — sand casting, centrifugal casting, shell mold, precision casting, forging, fabrication, extrusion, sheet, plate.

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top of its stroke, must just clear a valve leaf on the underside of the plate. If the gasket is too thin the piston will hit the leaf, and if the gasket is oversize the piston will fall short and reduce the compression ratio.

Gasket sheet homogeneous

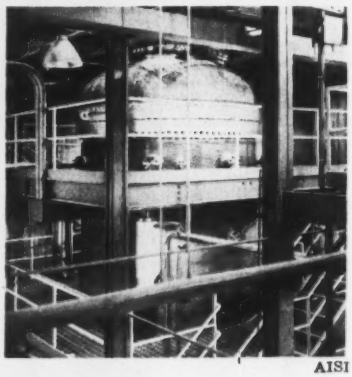
Controlled thickness and uniform compressibility and recovery are said to be inherent properties of Rogers Corp.'s Duroid 3102 used for the gaskets.

The material is produced by a beater addition process in which each asbestos fiber is saturated with neoprene and then formed into sheets. Encapsulation of the fibers gives a homogeneous material free of dead spots. Gasket blanks can be cut cleanly with a minimum fiber exposure at the edges.

Ceramic Lubricants Effective to 1500 F

The high temperature lubricating properties of several experimental ceramics promise to simplify designs where it is now necessary to cooi bearing surfaces or to move them away from the heat source.

In a research program on dry film lubricants conducted by the National Aeronautics and Space Administra-



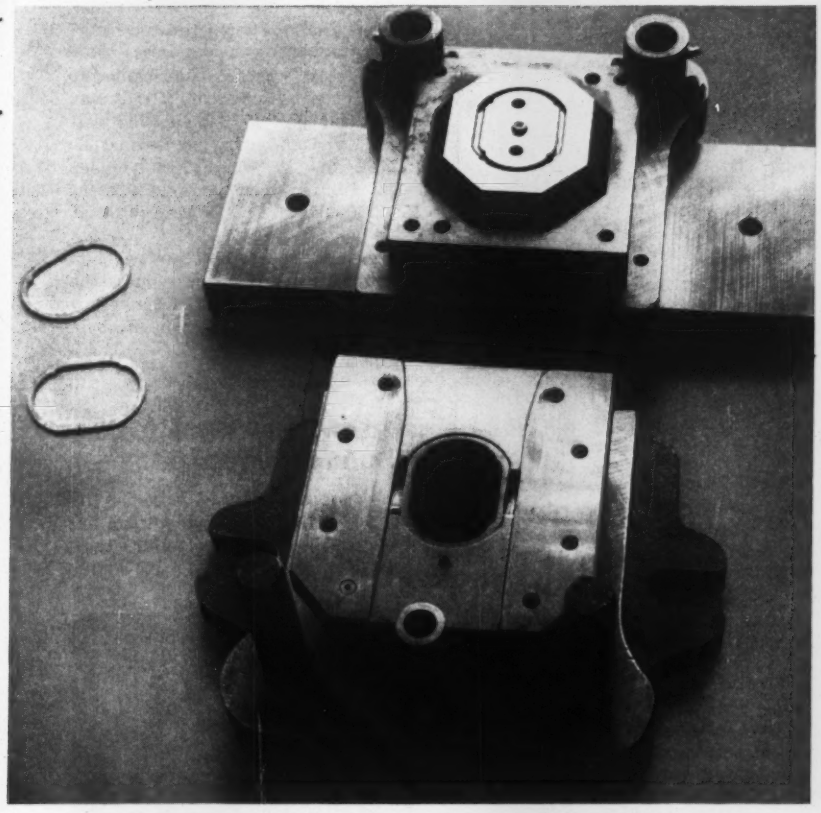
AISI

Stainless reactor vessel—The test reactor shown above uses stainless steel for the reactor vessel, heat exchanger piping, deuterium oxide (heavy water) storage tanks, and various filters.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation



Blanking die output up 300 per cent when they changed to Bearcat tool steel

Bearcat is the major grade of tool steel in this compound die which blanks and pierces an automotive piston strut at Art Stamping, Inc., Cincinnati. The die, hardened to Rockwell C57-59, was fed slugs of .075-gage C1035 hot-rolled steel. With the tool steel formerly used, an average of 115,000 pieces was produced. But with the change to Bearcat, more than 500,000 pieces were obtained before die failure. That's really cutting costs!

Bearcat is our super grade of shock-resistant tool steel. And it has plenty of wear-resistance for long runs. An air-hardening grade, it minimizes quenching hazards and distortion in heat-treatment.

Bearcat is ideal for blanking and forming dies, hot headers, shear blades, punches, and die-casting die inserts. In fact, it's right at home in any application calling for unusual toughness.

If you would like to put Bearcat to work in your shop, get in touch with your Bethlehem tool steel distributor. He has Bearcat in stock, in a wide size range. Give him a call today.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Lehigh H Still the Best Non-Distorting Tool Steel

Many of today's new tool steel grades are air-hardening types, such as Bethlehem's Bearcat and Air-4. Tests on these new air-hardening grades invariably show relatively low distortion in heat-treatment. Measurements on small test pieces, or on specific tools, often show size changes, resulting from hardening, of about .0002-.0004 in. per in. But due to over-enthusiasm, such results are often interpreted—and incorrectly—to indicate that the grades themselves are the long-sought "non-distorting tool steels."

However, tests on specimens of a variety of sizes and shapes show that individual dimension changes vary from zero to about .001 in. per in., averaging .0006-.0007 in. per in.

Production tools made from all medium alloy air-hardening tool steels will show low distortion to a degree which may eliminate many problems encountered with oil- or water-hardening tool steels.

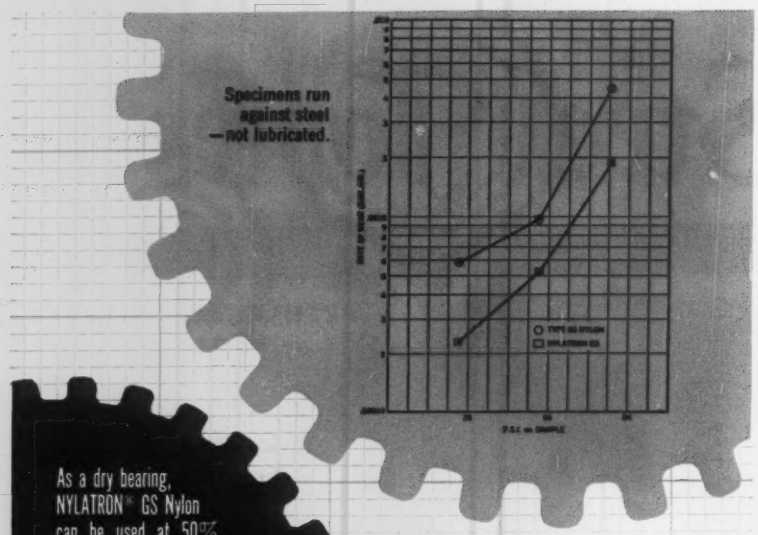
When considering the low distortion of these steels, remember that Lehigh H (AISI D-2) has even lower distortion. Furthermore, the distortion resulting from heat-treatment of tools made of Lehigh H is both predictable and controllable, even to zero distortion, if required. This can be accomplished by the austenite-martensite balance method described in Bethlehem's tool steel catalog.

Such medium alloy air-hardening tool steels as Air-4, A-H5, and Bearcat are good performers on distortion. But Lehigh H is the best of all.

TYPICAL ANALYSES

	C	V	Mn	Cr	Mo	Pb
Air-4	0.95	—	2.00	2.20	1.10	0.25
A-H5	1.00	0.25	0.60	5.25	1.10	
Bearcat	0.50	—	0.70	3.25	1.40	
Lehigh H	1.55	0.90	—	11.50	0.80	

For more information, turn to Reader Service card, circle No. 387



As a dry bearing, NYLATRON® GS Nylon can be used at 50% higher PV (pressure & velocity) ratings than standard type 66 nylon because it runs cooler, smoother and quieter with less friction to generate heat... maintains established fits and running clearances over a greater temperature range . . . and offers more rigid thin sections.

look
how much more
wear resistance
NYLATRON GS Nylon
gives your product

Increased abrasion resistance is only one advantage of NYLATRON GS over ordinary nylon. The nylon plus moly-sulphide composition* gives mechanical parts greater dimensional stability, increased modulus of elasticity, and improved flexural strength. In addition, GS Nylon molds accurately, ejects rapidly and handles easily on standard injection molding equipment.

Consider these NYLATRON GS advantages on your next design job. They promise you a superior product and cost-saving production.

For complete information about the unique properties and advantages of NYLATRON GS Nylon, call or write The Polymer Corporation

*Patented

POLYPENCO® *industrial plastics*

The Polymer Corporation • ***Molding Resins Division***
Reading, Pa.

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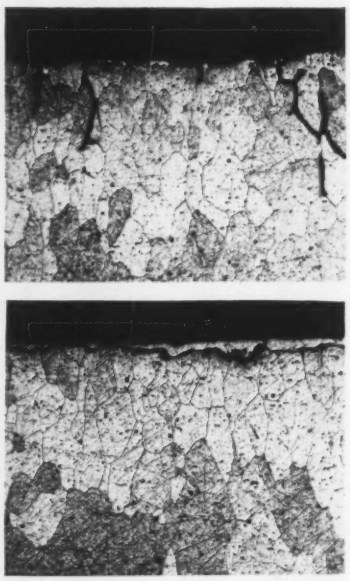
tion's Lewis Research Center, specimens riding at 430 fpm against metal disks coated with the experimental lubricants were tested under various loads at temperatures ranging to 1500 F.

The most effective lubricant for temperatures from 75 to 1500 F was found to be a ceramic-bonded calcium fluoride coating on Inconel X. Coatings containing 25% binder have friction coefficients of 0.26 at 75 F, 0.20 at 500 F and 0.15 at 1500 F.

Addition of a thin surface film of pure calcium fluoride reduces the friction at 1500 F to 0.06, but below 1350 F the pure film has no effect on friction.

Ultrasonics Best for Tinning Bus Bars

Corrosive fluxes used in solder tinning of high strength aluminum bus bars can cause intergranular cracking. But a way to avoid this diffi-

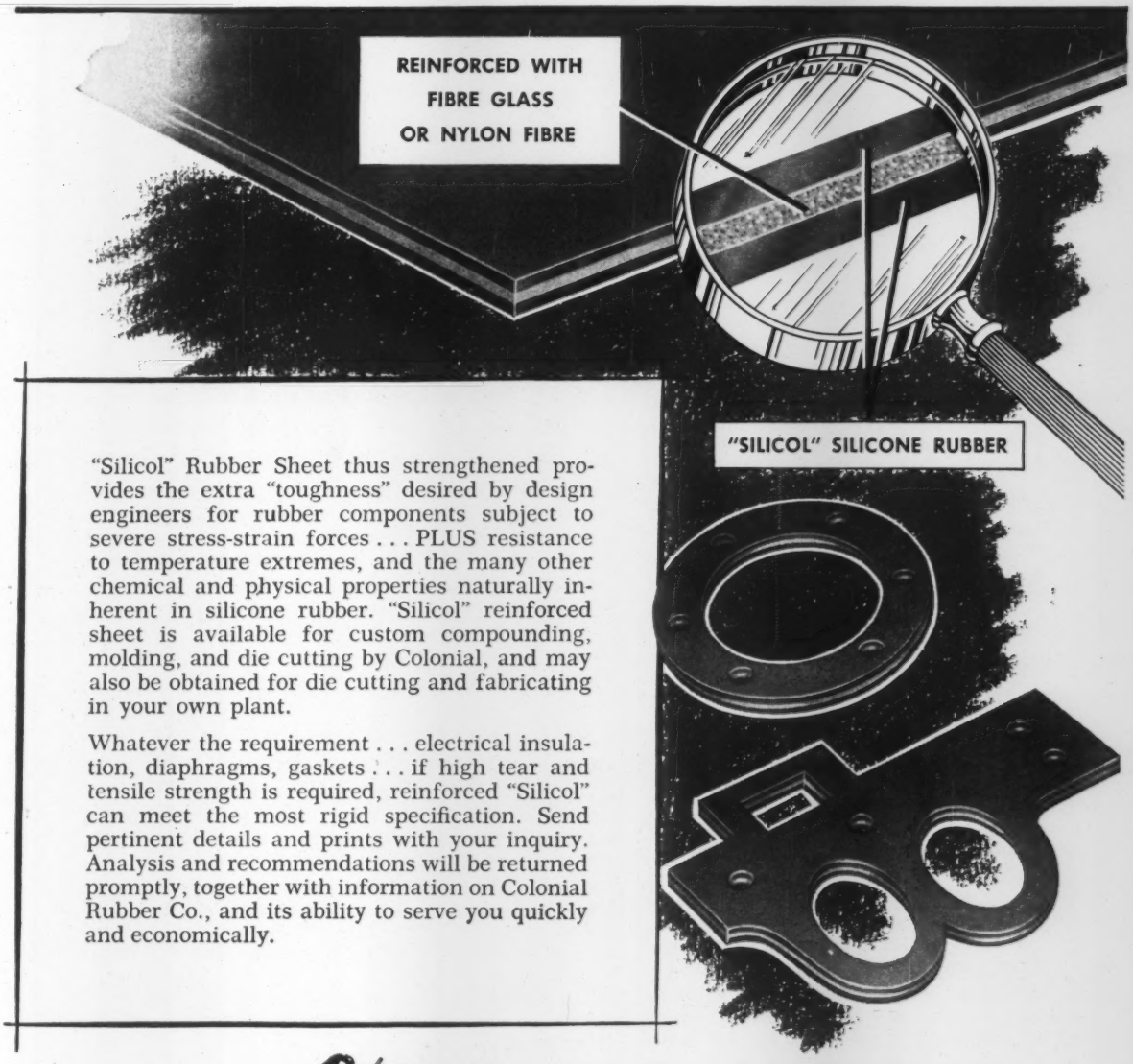


***Cross sections** of aluminum bus bars tinned by soldering with a flux and by ultrasonics. The soldered bus bar (top) has intergranular penetration but the ultrasonically tinned bar (bottom) does not.*

•Design your seals and gaskets for

100% GREATER TENSILE and TEAR STRENGTH

with "SILICOL"* SILICONE RUBBER SHEET



"Silicol" Rubber Sheet thus strengthened provides the extra "toughness" desired by design engineers for rubber components subject to severe stress-strain forces . . . PLUS resistance to temperature extremes, and the many other chemical and physical properties naturally inherent in silicone rubber. "Silicol" reinforced sheet is available for custom compounding, molding, and die cutting by Colonial, and may also be obtained for die cutting and fabricating in your own plant.

Whatever the requirement . . . electrical insulation, diaphragms, gaskets . . . if high tear and tensile strength is required, reinforced "Silicol" can meet the most rigid specification. Send pertinent details and prints with your inquiry. Analysis and recommendations will be returned promptly, together with information on Colonial Rubber Co., and its ability to serve you quickly and economically.

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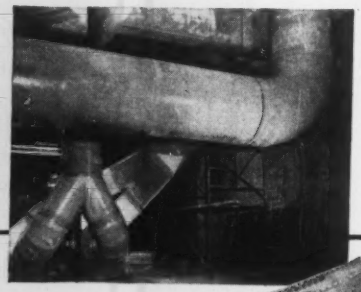
corrosion resistant **DURACOR**

replaces costly metal fabrications

in the
METALWORKING
industry

Ceilcote engineers complete ventilating systems, gas scrubbing towers, hoods, tank covers, ducts, recovery tanks and other customized fabrications.



in the
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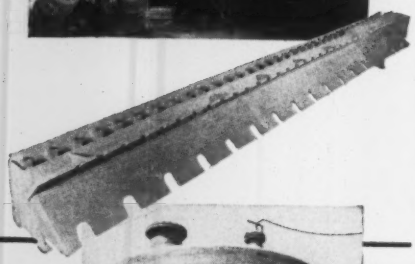
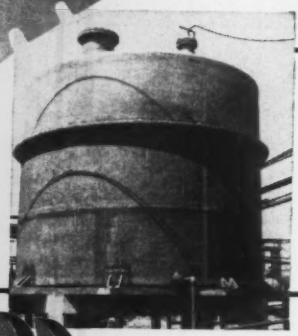
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



in the
PETROLEUM
industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



in the
CHEMICAL
industry

Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

PHYSICAL PROPERTIES

Tensile Strength p.s.i.: 11,000-15,000

Flexural Strength p.s.i.: 20,000-30,000

Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6

Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6

Impact Izod, Notched ft.-lbs./in.: 30—40

Specific Gravity: 1.4

Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.

Standard Color: Light Green/Gray

Maximum Temperature (Exposure): To 500°F.

Save up to 40% over costly metal structures with Duracor processing equipment and ventilating systems! A product of Ceilcote's 33 years of corrosionproofing experience, Duracor combines extreme chemical resistance and high strength with light weight, heat and flame resistance. WRITE TODAY FOR VISUAL STANDARDS AND INDUSTRY SPECIFICATIONS!

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DURACOR CEILCOTE

8595-CC

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culty is to use electroplating or ultrasonic tinning.

These are the conclusions derived by C. L. Carlson of Westinghouse Electric Corp., Materials Laboratories, East Pittsburgh, Pa., after conducting a series of tests on two sets of bus bars. One set was straight and the other set was slightly bent to set up residual stresses before tinning. Both sets were tinned by electroplating, by ultrasonic soldering and by flux soldering. The tinned bars were then bent 90 deg to obtain the normal amount of strain associated with right angle bends. The bars were bent because they usually require many right angles as well as less severe bends in fabricating operations.

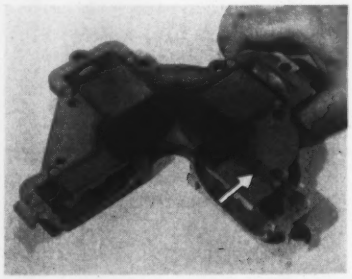
Epoxy Adhesive Solves Pump Casting Problem

Use of three adhesive-bonded die castings has solved a difficult and expensive problem in the design of pump castings.

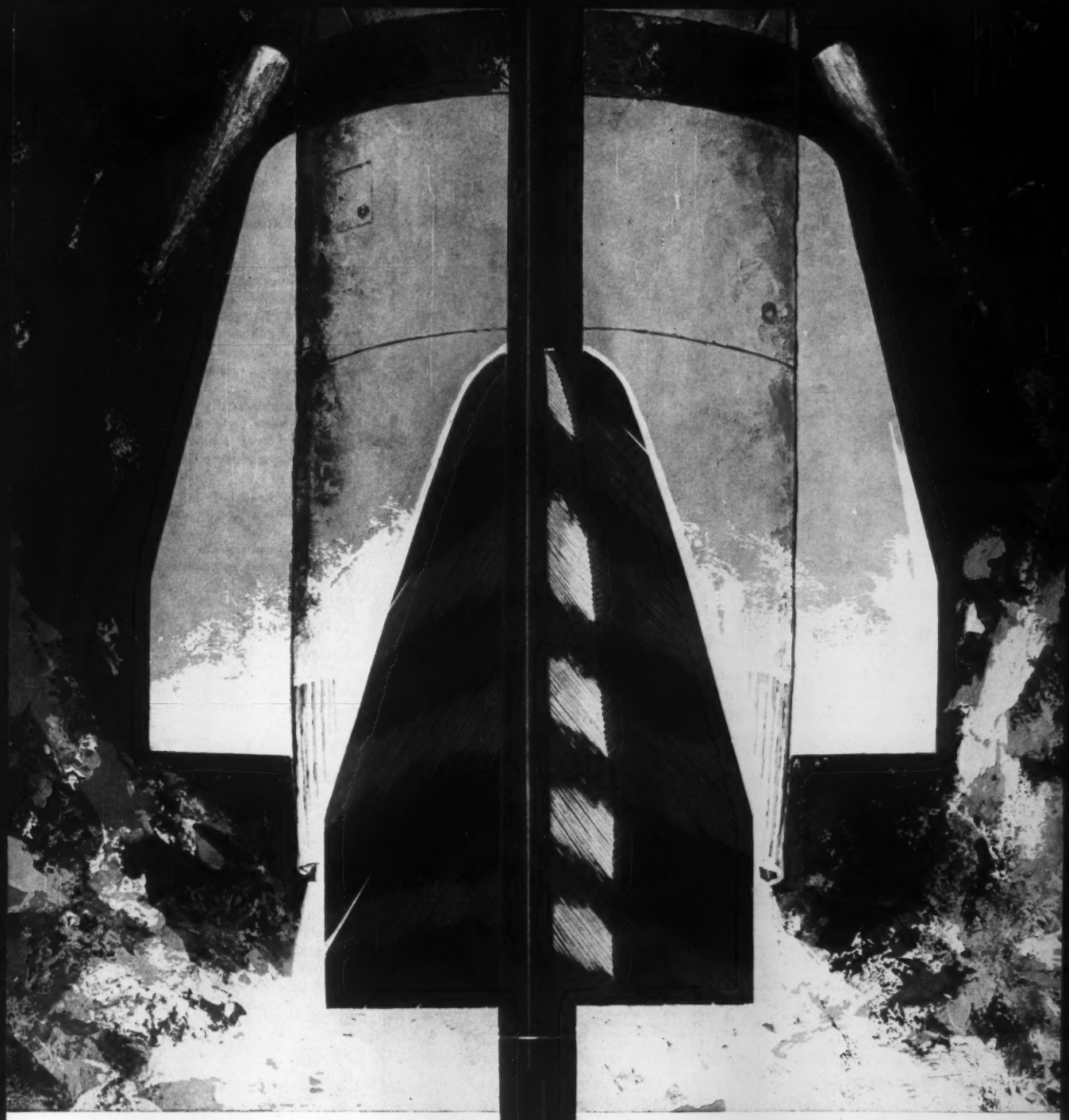
Previously, pumps were made in one piece by sand casting. However, because of the complex interior design of the casting, blow holes occurred quite often and resulted in rejection rates as high as 25%, or a loss of about $750 per 1000 castings.

Now, the pumps are made from three separate, adhesive-bonded die castings. The adhesive used is a one-part, high strength epoxy-base material developed by Minnesota Mining & Mfg. Co.

According to MMM, adhesive bonding was selected over other joining



***Cut-away section** of pump assembly showing the three adhesive-bonded die castings.*



Swedlow

MATERIONICS

Stone age profile on a space age missile. But in performance: progress in the science of fabricating advanced materials. In Swedlow language: MATERIONICS. In Swedlow practice: the insight to solve challenging problems of design and producibility of transparent plastic glazing, high temperature reinforced plastics—laminates, complex shapes, difficult parts—suppliers of flame resistant flexible coatings. Write for Facilities Report "Z," to Dept. 18

For more information, circle No. 357

SWEDLOW Inc. / LOS ANGELES 22, CALIFORNIA / YOUNGSTOWN 9, OHIO

Roll Back The Thermal Barrier ....

with **CHROMALLIZING**

Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

A recent Chromalloy development, IOCHROME (99.997% pure chromium), is a basis for chromium alloys for use at 2500°F.

Write for illustrated BULLETIN MH

Chromalloy corporation

169 Western Highway • West Nyack, N. Y.
ELmwood 8-5900

CHROMIZING CORPORATION, LOS ANGELES, CALIFORNIA
PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
Propellants, cartridge actuated devices, explosives and special chemicals.
ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO. Quality gray iron castings.
SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

For more information, turn to Reader Service card, circle No. 361

methods because:

1. It eliminates the lugs, bolt holes and flanges necessary with mechanical fastening, in turn eliminating additional expensive and time-consuming machining operations.
2. It automatically seals the three sections at the time of bonding, thus eliminating cost and time of separate sealing and/or gasketing operations.
3. It does not require the high heat necessary for brazing or welding operations.
4. It eliminates the use of corrosive fluxes and expensive neutralizing operations.
5. It allows the use of lower cost casting materials.
6. It eliminates the necessity for skilled labor.
7. It is adaptable to both short and continuous production runs.

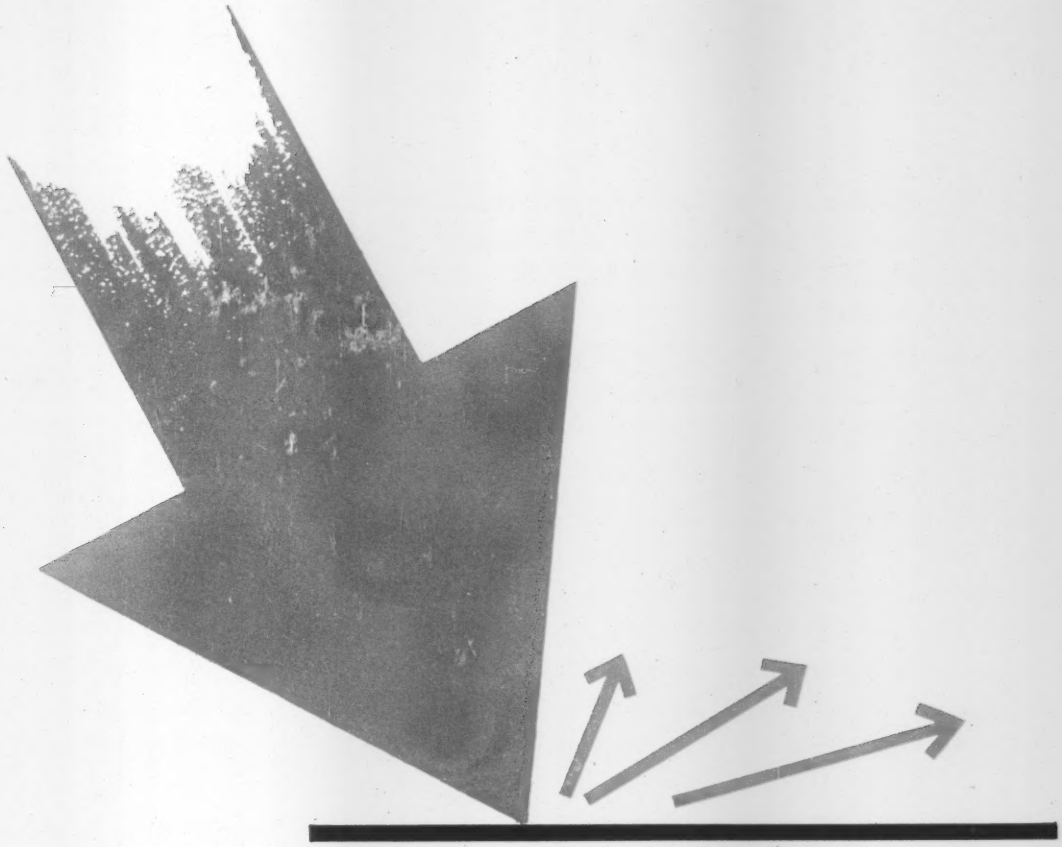
Multiple Creep Tester Cuts Time, Cost

A flexural creep test machine which tests 15 specimens at a time is said to have cut five years and five months—and 5/6 of the cost—from a plastic laminate materials test program at Boeing Airplane Co.

The tester consists of an enclosed chamber housing 15 loading rods. Weights placed on the rods apply desired breaking loads to test specimens beneath them.

A sealed water-filled base provides

***Deflection measurements** are taken on the loading rods of the multiple creep test unit with a dial indicator.*



Metallurgical Phenomena... and the metals to cope with them.

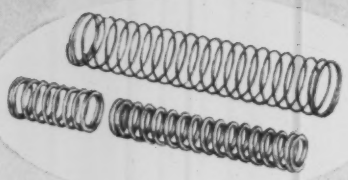
These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of abrasive impact (symbolized above) or corrosion or pressure or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: Joe Proctor, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

For more information, turn to Reader Service card, circle No. 401

Spotlighting Reliability!

MICRO-PROCESSED I-S BERYLLIUM-COPPER SPRINGS

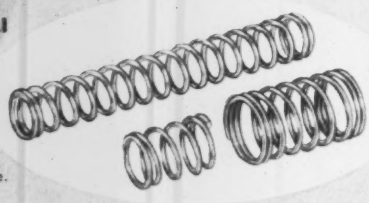


Exclusive Design Advantages

I-S micro-processed beryllium copper springs, designed into control devices, relays, circuit breakers, etc., result in improved performance and lower cost. Their high degree of uniformity eliminates the necessity of hand adjustment during assembly and is your guarantee of uniform performance.

Important Electrical Advantages

I-S micro-processed beryllium copper springs receive laboratory-proven heat treatment, therefore they can operate at higher temperatures and carry more current with less temperature rise.



THE *Ideal* SPRING MATERIAL

Beryllium copper is an ideal spring material because of its natural inherent characteristics. It is non-magnetic, has the corrosion resistance of pure copper, high electrical conductivity, high wear resistance and a high endurance life. The temperature used to develop spring temper also serves to relieve internal stresses remaining from cold work. The ability to conform to jigs and holding fixtures during heat-treatment makes it particularly well suited for our specially designed, patented machines. The wire is placed upon the mandrel in an exacting manner, strictly in accordance with the engineered design. The springs are set to this design by heat-treatment while they are still on the mandrel. There is no spring back upon removal from the mandrel with the result that the springs are uniform, stable and free from drift.

CALL OR WRITE FOR THE I-S CATALOG covering in detail compression springs, flat springs, strip springs, contact rings, contact strips and screw machine products.

IN SWEET'S PRODUCT DESIGN FILE

INSTRUMENT SPECIALTIES CO • INC

"MICRO- ...PROCESSED" I S BERYLLIUM COPPER SPRINGS

224 BERGEN BLVD. LITTLE FALLS, N. J.

Telephone: CLifford 6-3500

For more information, turn to Reader Service card, circle No. 366

a constant-temperature environment up to 200 F.

The program involved testing more than 1000 epoxy laminate tooling materials at constant stresses from 3% to 50% of breaking load for periods of 500 hr at room temperature and 120 F.

Plastics Sleeves Speed Superheater Assembly

Inexpensive polyethylene sleeves, placed over superheater pipes while the refractory walls are cast, melt at start-up to form uniform expansion gaps through the walls.

One boiler manufacturer says that using the sleeves cuts 80 hours from the assembly time of each boiler, a saving of about $350.

Replace asphalt, paper wraps

The split sleeves, made by Anchor Plastics Co. from its Aeroflex material, replace hand operations in which the 700 to 1000 sections of pipe passing through a superheater's walls were wrapped with paraffin paper or painted with asphalt.

Equally as important as the time and money saved, say engineers, are the precise gaps (±0.005 in.) the sleeves leave between the steam line and refractory wall. Ideally, the hot line should just fill the hole. If the fit is too tight the refractory might crack; a loose fit permits heat loss and lowers efficiency.

Sleeves slip onto pipes

The flexible sleeves, slit up one side, are slipped onto the pipe sections before the pipes are welded together and the refractory poured. Since the sleeves do not absorb moisture, they do not weaken the refractory while it is setting.

After start-up, when the pipe temperature reaches about 250 F, the polyethylene melts completely, leaving a smooth seat between pipe and wall.

AWARDS COMPETITION—Entries for the 5th annual Awards Competition for the Best Use of Materials in Product Design are due Feb 1, 1960. See p 16 for full details.

VANADIUM-ALLOYS CVM
CONSUMABLE VACUUM MELTED STEELS

from the world's most modern ultra-high vacuum melting furnace

Cleaner, tougher, stronger steels fit for the meticulous specifications that frame today's new uses on earth, in air or in space—steels that perform beyond all previous standards because of Consumable Vacuum Melting, under precise control. • Every *First Quality* Vanadium-Alloys steel is a finer steel when CVM processed: the table at right is typical. If your application requires the utmost from a specific grade, the moderate extra cost of CVM will prove a sound investment. *Let us go over the facts with you, at your convenience.*

CVM GRADES NOW AVAILABLE

VASCOJET 1000	AISI 4350	VASCO M50
AMS 52100	A286	STAINLESS 410
AMS 51100	STAINLESS 430	INCO 901
STAINLESS 440 C	AMS 6434	300 M
STAINLESS 440 C MODIFIED	VASCO M1	AISI 9310
D6-AC	VASCO M2	STAINLESS 316
AISI 4340	VASCO M10	STAINLESS 317

Special compositions of any kind will be made to customers' requirements.

What CVM does for a fine air-melted steel: VASCOJET 1000

EFFECT OF CONSUMABLE ELECTRODE VACUUM MELTING ON TRANSVERSE DUCTILITY OF VASCOJET 1000 AT 280-310,000 PSI

Representative billets and bars from multiple heats. Four to six tensile bars cut transversely from midradius of each piece and heat treated to 280-310,000 psi ultimate tensile strength.

Cross Section	Avg. Transverse Reduction of Area (280-310 ksi) Consumable Vacuum Melt	Air Melt
16″ square	21%	7%
12″ square	22	10
9½″ round	27	11
9″ square	30	11
7″ round	31	12
7″ square	35	12

VANADIUM-ALLOYS STEEL COMPANY

GENERAL OFFICES: LATROBE, PA.

DIVISIONS: Anchor Drawn Steel Co. • Colonial Steel Co. • Metal Forming Corporation • Pittsburgh Tool Steel Wire Co. • Vanadium-Alloys Steel Co.

SUBSIDIARIES: Vanadium-Alloys Steel Canada Limited • Vanadium-Alloys Steel Societa Italiana Per Azioni • EUROPEAN ASSOCIATES: Societe Commentryenne Des Aciers Fins Vanadium-Alloys (France) • Nazionale Cogne Societa Italiana (Italy)

FIRST QUALITY TOOL & SPECIAL STEELS

For more information, turn to Reader Service card, circle No. 389

M&T Spray-on Vinyl Finish goes on thick without loss of pattern detail

A THICK PROTECTIVE MANTLE that mirrors the underlying metal pattern is a real accomplishment. But new M&T vinyl organosols now produce it routinely. These spray-on coatings also provide a textured finish to *smooth* metal.

Along with this versatility, M&T vinyl finishes give you exceptional durability. They can be sprayed up to 15 mils thick. Such a thick film protects against acids, caustics, water, grease — and shrugs off physical abuse without chipping, marring, peeling. It insulates electrically and thermally. It resists abrasion. It muffles noise. Typical use: architectural products.

These amazing finishes offer production benefits, too. They're sprayed on, in any color, *after* fabrication of the parts from smooth or mill-patterned metal. This eliminates raw edges, allows reclamation of rejects. Write for more information.

M&T coatings and finishes
METAL & THERMIT CORPORATION
General Offices: Rahway, New Jersey

For more information, turn to Reader Service card, circle No. 402

(cont'd from p 18)

What's new IN MATERIALS

Adhesives for Wood, Plastics

Good heat resistance, high bond strength and good storage stability are some of the claims made for a variety of new adhesives now on the market. The adhesives are designed for both consumer and industrial applications.

1. Adhesives for high temperatures

Radiation Applications, Inc., 36-40 37th St., Long Island City, N. Y. has developed three adhesives for high temperature applications. The adhesives are available in developmental quantities. They are called Raiseal.

No. 100 is a silicone rubber-base adhesive that withstands temperatures up to 700 F. It is especially useful for encapsulating electrical and electronic parts.

No. 200 is a paste adhesive especially useful for sealing and encapsulating. It has good resistance to acids, alkalis and fuels. It can be used at temperatures up to 800 F. Composition has not been disclosed.

No. 300 is a rigid structural adhesive that can be used at temperatures from 600 to 1000 F. Its composition has not been revealed.

KEY NO. 609

2. Adhesive for vinyl foam

A flexible rubber-base adhesive bonds closed-cell vinyl foam to itself and to fabrics, plastics, metals, wood and other materials. It is called Bondmaster R379-20 and is available from Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J.

The adhesive has been specially formulated to resist the solvent attack of vinyl marine coatings commonly used with vinyl foams. It is also said to resist salt water, high humidity, hot oil, gasoline, aromatic fuels and organic solvents. It can be used at temperatures up to 350 F.

KEY NO. 610

3. Adhesives for wood

Four new polyvinyl acetate adhesives for wood are being marketed by Borden Chemical Co.'s Resins & Chemicals Dept., 350 Madison Ave., New York 17. They are sold under the name Cascorez. The adhesives are designed specifically for assembly of prefabricated cabinets, partitions, furniture and doors.

CV-735 is a high tack, high joint strength emulsion for applications where wet tack is required. The adhesive has excellent freeze-thaw stability, six-month storage life, and a viscosity of 3000-4000 cps.

CV-731 is a medium solids, low cost adhesive for applications where medium joint strength is sufficient and cost is of primary concern.

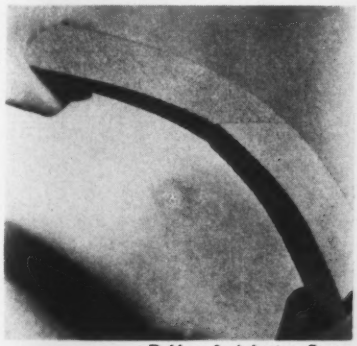
CV-728 is a medium solids, fast setting, moderate cost adhesive. It has a four-month storage life and a viscosity of 3500-4000 cps.

CV-737 is a fast-setting, high joint strength adhesive. It has a viscosity of 3500-4800 cps, excellent freeze-thaw stability, and a six-month storage life.

KEY NO. 611

4. Adhesive for laminates

Bostik No. 7008 is the name given to a quick-drying adhesive designed for bonding plastics, glass and metals to themselves and to other materials. It is especially useful in fabricating speaker coils, laminated circuits, multiple contact assemblies and other components in which



Rubber & Asbestos Corp.

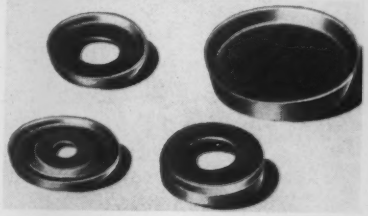
***New adhesive** effectively bonds vinyl foam to itself and to other engineering materials.*

RULON® TEFLON

RULON — first practical fluorocarbon for cup packings

Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.



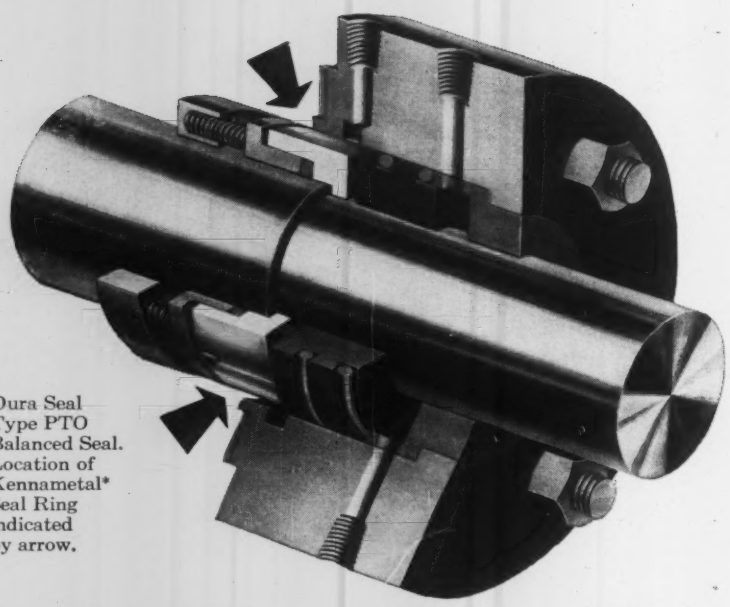
RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

For more information, circle No. 393



Dura Seal Type PTO Balanced Seal. Location of Kennametal* Seal Ring indicated by arrow.

It's tough to seal ethylene . . . but it can be done with KENNAMETAL

Single mechanical seals for ethylene and other light hydrocarbons must operate for several minutes at a time in vapor, without benefit of liquid lubrication. The seal and mating faces must therefore be able to operate virtually dry during these periods, at pressures up to 600 p.s.i., without damage to the seal faces.

For this difficult sealing job, Durametallic Corporation has found Kennametal Seal Rings superior to either cast alloy or ceramic rings. Kennametal rings can operate successfully with a minimum of lubrication. Kennametal stands the additional loading imposed by these adverse conditions. provides stability under high temperatures, and resists thermal shock.

On one ethylene pumping application, several "Dura Seals" with Kennametal rings have been operating for well over a year. Customer satisfaction has led to the purchase of additional seals for similar use.

To seal gases, exotic fuels, fluids, slurries, acids, basic solutions, synthetic and petroleum base fuels, organic solvents, butyl extracts . . . *Specify Kennametal* for exceptionally good dimensional stability, for successful sealing of a great variety of media, for strength without great mass, for corrosion and wear resistance, and for high temperature applications.

Send for these booklets: B-111-B—"Properties of Kennametal" and B-666—"Proven Uses of Kennametal and Kentanium.*" Write Dept. MDE, KENNAMETAL INC., Latrobe, Pennsylvania.

Note: Kennametal Inc. makes seal *rings* used by leading manufacturers of seals.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material and/or exceptional stability at temperature extremes

3354

INDUSTRY AND KENNAMETAL ...Partners in Progress

For more information, turn to Reader Service card, circle No. 343

What's new IN MATERIALS

phenolic-impregnated fabric is adhered to metal.

The adhesive (composition of which has not been revealed) was developed by B. B. Chemical Co., 784 Memorial Dr., Cambridge, Mass.

The developer says the adhesive will bond effectively at room temperature, but a thermosetting reaction occurring at 250 F or above provides maximum bond strength. The adhesive has a solids content of 28%, is amber colored, has a six-month storage life in closed containers, and is odorless. KEY NO. 612

5. Adhesives for plastics

Two new water-base latex adhesives are said to be excellent for bonding unsupported plastics films to cotton, wood, leather, paper and foam rubber. Introduced by Adhesive Products Corp., 1660 Boone Ave., New York 60, they are called Plastix Wet Stick and Plastix Heat Seal.

Wet Stick is suitable for flocking on vinyl and other plastics and can be used on thin-gage plastics films without wrinkling.

Heat Seal is suitable for attaching decorative ornaments to toys and other products.

The two adhesives are said to dry rapidly to form transparent, tack-free surfaces that do not discolor materials being bonded. The adhesives form a strong bond that resists both washing and dry cleaning.

KEY NO. 613

Alloy Steel for Auto Anti-Smog Devices

A new alloy steel is designed specifically for use in automobile anti-smog devices.

The steel, called 21-6-9 and developed by Armco Steel Corp., Middletown, Ohio, is said to be better and less costly than most standard grades of stainless steel currently being evaluated for anti-smog devices. It sells for 72.25¢ per lb in the form of sheet and cold rolled strip.

Nominal composition of the alloy is: chromium, 21%; nickel, 6%; and manganese, 9%.

Tests show the steel retains its strength at high temperatures and

"Is that the new Norton catalog?"

You bet it is!

It's dog-eared and marked up because it's in constant use by men who want better materials — high purity refractory materials which will stand up under the most extreme thermal, mechanical, chemical, electrical, and radioactive conditions.

This valuable, well-illustrated reference describes in detail the many Norton refractory materials which are helping to solve widely different product and processing problems. Uses range from aiding chemical reactions to stopping neutrons, handling molten metals, protecting rocket engines — and taming lightning.

Catalog lists physical, chemical and electrical properties of CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, NORBIDE* Boron Carbide, and Fused Zirconia. It's thought-provoking...a real "idea-starter!"

You may well profit from this book in solving your own processing problems. No charge or obligation, of course, write for "Norton Refractory Grain,"

NORTON COMPANY, Refractories Division, 340 New Bond St., Worcester 6, Mass.

*Trade-Marks Reg. U.S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of... Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more information, turn to Reader Service card, circle No. 367

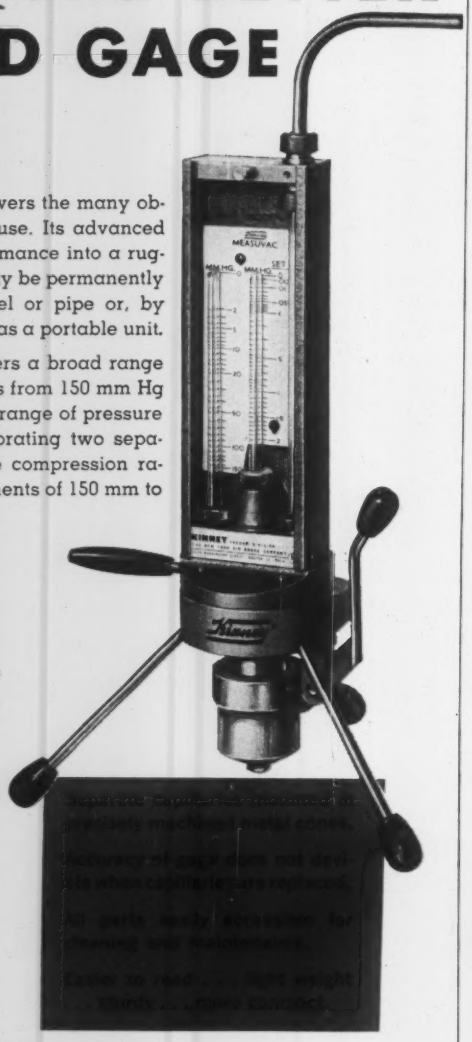
Kinney®

PRESENTS A

much smaller

~~BIGGER~~ and BETTER

McLEOD GAGE



The KINNEY McLeod Gage answers the many objections to other gages now in use. Its advanced design compacts superior performance into a rugged, versatile instrument that may be permanently mounted on bracket, tank, panel or pipe or, by affixing demountable legs, used as a portable unit.

The KINNEY McLeod Gage covers a broad range of pressures... accurate readings from 150 mm Hg to 1 Micron Hg. This exceptional range of pressure readings is achieved by incorporating two separate capillaries having separate compression ratios, making available measurements of 150 mm to 2 mm and 2,000 microns to 1 micron. Unlike other McLeod Gages, the reading capillary tubes are completely separate and replaceable – easily detached from the main body at the knurled sealing glands. Because these tubes are reproducible, complete accuracy between each gage is assured.

The KINNEY McLeod Gage requires less mercury and it is supremely simple to add mercury, remove it for cleaning or recharge the gage. Operation requires no special skill . . . readings are achieved quickly, easily and confidently. Write for full information and prices today.

Get all the facts on the NEW KINNEY McLEOD GAGE. Write today!

KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY
3523A WASHINGTON STREET • BOSTON 30 • MASS.

Please send me Bulletin No. 3821.1 and prices on the KINNEY McLeod Gage.

Name_____

Company_____

Address_____

City_____ State_____

For more information, turn to Reader Service card, circle No. 416

has good resistance to lead salt attack. It can be worked and fabricated by conventional methods.

Anti-smog and other uses

Two methods are now under consideration for removing harmful hydrocarbons from automobile exhaust streams. One uses a catalytic device and the other a thermal afterburner. The new steel is expected to be used in both types of devices.

Other uses foreseen for the alloy are catalyst supports, heat exchanger parts, and other parts where temperatures reach or exceed 1600 F.

KEY NO. 614

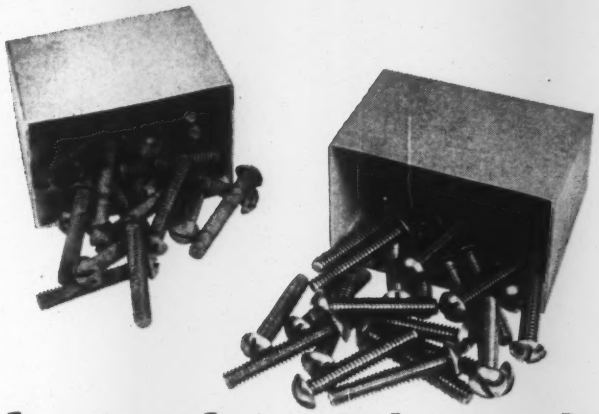
Asbestos Sheets Are Decorative, Durable

Decorative asbestos-cement sheets in prefinished, permanently colored form are now available from Keasbey & Mattison Co., Ambler, Pa. They can be used as curtain walls, partitions and siding.

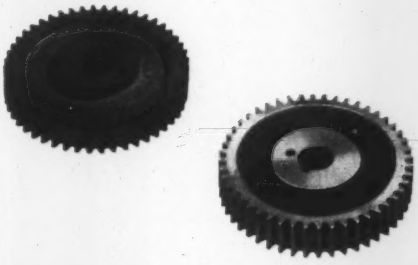
The new colored sheets are said to have a hard, smooth, decorative finish with about five times the life of ordinary paints. They can be drilled and sawed without cracking or chipping the colored surface.

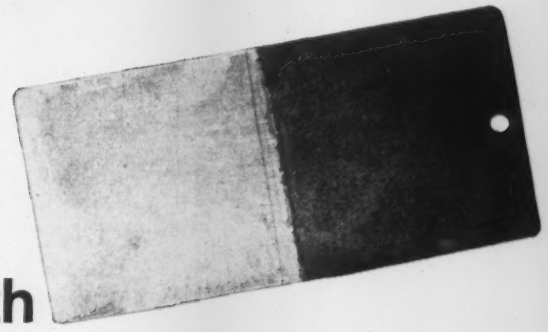
Weatherometer and natural exposure tests indicate that the colors do not fade and have excellent resistance to chalking. The finish is

***Color technologist** studies color combinations possible with new asbestos-cement sheets.*



Whatever form of metal you handle...





prevent corrosion with SOLVAY SODIUM NITRITE

Your iron and steel parts in process—of every size, shape and type—will resist corrosion if you treat them with Solvay® Sodium Nitrite. Dissolved in water in economical, low concentration, it coats the corrosion-free parts pictured above—striking contrast to the untreated, corroded mates.

This easy-to-apply protection coats metal surfaces with an invisible gamma oxide film. Spray or dip it on in solution—add it to circulating water systems—combine it with phosphates for greater moisture resistance. It also reportedly suppresses degradation in aluminum, tin, monel, copper and brass.

Write for further information and a test sample.

Sodium Nitrite • Caustic Soda • Calcium Chloride • Chlorine • Chloroform Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash Ammonium Chloride • Methyl Chloride • Ammonium Bicarbonate • Vinyl Chloride Methylene Chloride • Cleaning Compounds • Hydrogen Peroxide • Aluminum Chloride • Mutual® Chromium Chemicals • Snowflake® Crystals • Monochlorobenzene • Ortho-dichlorobenzene • Para-dichlorobenzene • Carbon Tetrachloride

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

SOLVAY branch offices and dealers are located in major centers from coast to coast. Send export inquiries to Allied Chemical International, 40 Rector St., N. Y. 6.

SOLVAY PROCESS DIVISION 42-11
Allied Chemical Corporation
61 Broadway, New York 6, N.Y.

Please send me without cost:

☐ A. Test sample of Solvay Sodium Nitrite
☐ B. Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"—SP-33A

Name_____
Position_____
Company_____
Phone_____
Address_____
City_____ Zone____ State_____

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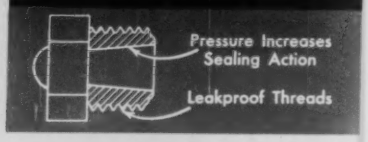
it's new
it seals
it saves



it's DELRIN*

Another RB&W development from Delrin plastic, this new threaded plug replaces more expensive metal plugs in many hydraulic and compressor applications.

It not only saves on cost and weight, but also does a better job. Fluid pressure forces mating threads together, creates a still tighter seal, locks threads in place.

Metal-like mechanical properties of Delrin provide excellent strength, dimensional stability, rigidity. Count also on resistance to corrosion and solvents.

Available in ⅛, ¼, ⅜, ½" pipe sizes. Send for samples.

Ask about other parts you would like custom-molded from Delrin, or other thermoplastics, in production quantities.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

R B & W
116th year

For more information, circle No. 411

What's new IN MATERIALS

corrosion resistant and does not contribute to the growth of mildew or fungi.

According to the developer, the decorative finishes are not stained by ink, animal fats, mineral oils, grease, lipstick, coffee, tea or liquor.

KEY NO. 615

Improved Epoxy Paint

An improved, one-part epoxy coating for metals and other materials is now available from Industrial Finishes Co., Inc., 1119 Land Title Bldg., Philadelphia 2. The coating, called EP-ACK, has been modified with a new chemical called pyromellitic diandydride that is said to improve the coating's resistance to acids, alkalis, salt spray and humidity.

The coating can be air dried or oven baked. KEY NO. 616

Intermetallic Can Be Magnetic, Nonmagnetic

Chromium manganese antimonide, $Mn_{(2-x)}Cr_xSb$, an intermetallic compound discovered by scientists in Du Pont's Central Research Dept., has varying ferromagnetic properties. At or above a given transition temperature, which depends on the composition of the compound, the antimonide becomes ferromagnetic. Below the transition temperature, the compound is nonmagnetic.

As temperature increases above the transition temperature, magnetization decreases, finally disappearing at the Curie temperature (480 F in the case of compositions with room temperature transition).

Manganese antimonide itself is a ferromagnetic substance; introduction of chromium in proper quantity produces the unusual properties.

Transition temperature can be adjusted by varying the proportion of chromium in the compound. Experiments indicate that the transition temperature can be varied from near absolute zero to over 212 F. While the maximum magnetization of most magnetic materials occurs near absolute zero, the new compound exhibits

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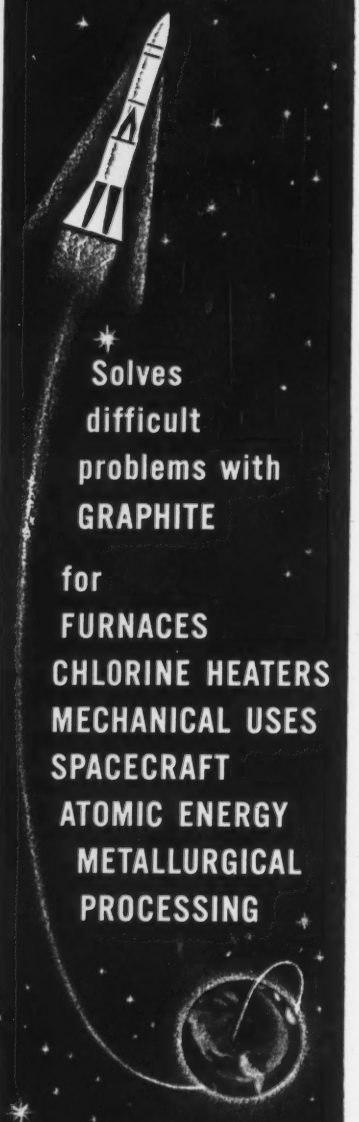

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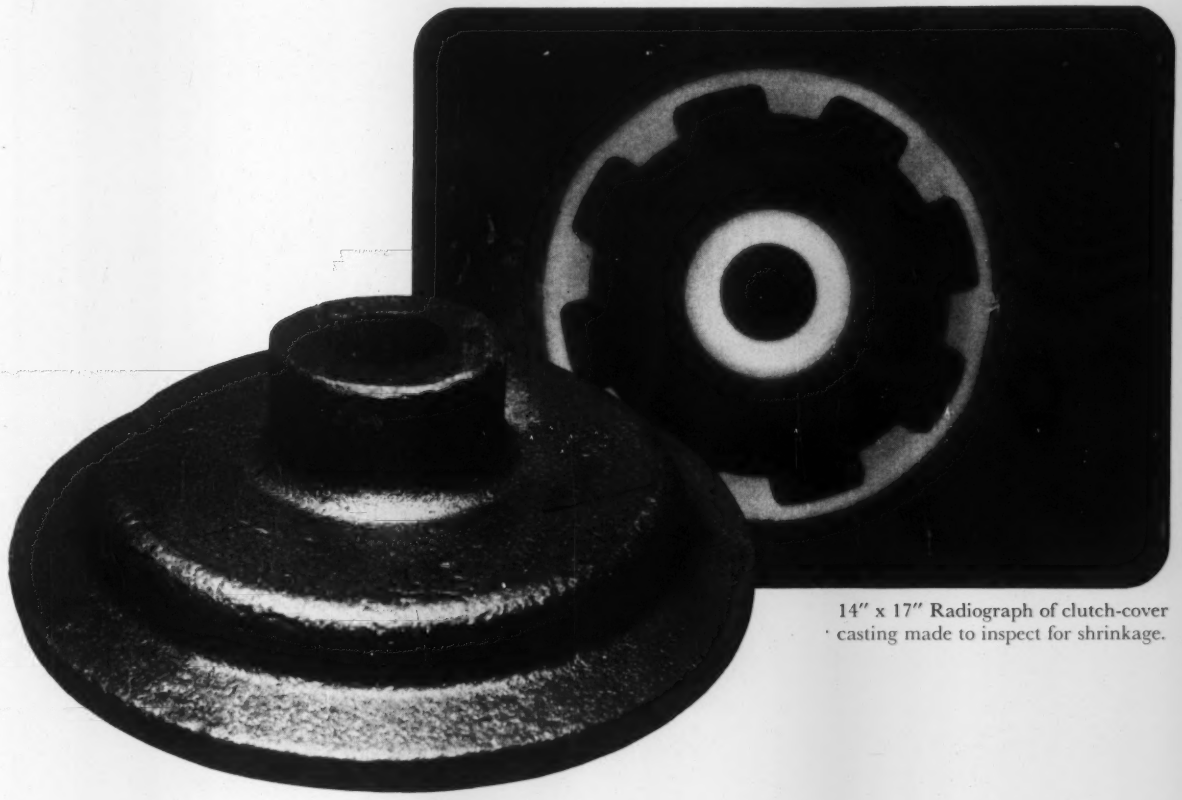

14" x 17" Radiograph of clutch-cover casting made to inspect for shrinkage.

The grip that moves mountains must not be broken

Clutches on heavy earth-moving equipment must literally grip with a cast-steel hand. Riverside Foundry, Bettendorf, Iowa, checks the reliability of its clutch-cover castings with radiography.

One of Riverside Foundry's customers makes huge and powerful earth-moving vehicles. Every part must contribute to their stamina—especially the parts that handle the hundreds of horsepower that drive them.

In order to make sure that the castings they deliver are sound and ready for this demanding job, Riverside Foundry of Bettendorf, Iowa, radiographs them, using Kodak Industrial X-ray Film.

This is one of the ways foundries, large and small, are today making certain only high-quality work goes to their customers. They find radiography helps build their reputations and their business.

Radiography can work profitably for you. How? Talk it over with an x-ray dealer or write for a Kodak Technical Representative to call.

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Just a fingerprint—yet the amount of salt deposited by it is enormous compared to the infinitesimal (less-than-one-part-per-million) chloride content a modern electrolytic capacitor can tolerate. When the chloride limit is exceeded, even slightly, corrosion begins.

"Maintaining this extremely low level," cautions P. R. Mallory & Co., Inc., one of the country's leading producers of capacitors, "calls for a great deal of cooperation between our material suppliers and our handling methods . . ."

The problem presented to Plenco by Mallory engineers was thus precise and challenging: *Provide a phenolic compound for the molding of capacitor casings that is within one part per million chloride-free.* In addition, other vital requirements for the plastic cases demanded minimum moisture absorption, dimensional stability and maximum heat resistance.

Special needs in a special combination. A challenge that was met in typical Plenco fashion. By adhering to uncompromising standards of research and quality manufacture, Plenco engineers created a custom-designed formulation that ideally answers the exacting Mallory specifications. Result: Mallory Plastic Case Electrolytic AC Capacitors—virtually 100% chemically pure—are as failureproof as electronics science and advanced phenolics engineering can make them. Capacitors that are outstanding for dependability in their countless applications, and are recognized to be the standard of the industry.

Through a broad background of specialized knowledge and success-tested experience, as well as an extensive selection of general and special-purpose phenolic molding compounds, Plenco contributes importantly to many industries. We'd like the opportunity to demonstrate that to you. Call us for consultation at any time.

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. . . already made or specially made

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Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

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this maximum at or slightly above the transition temperature.

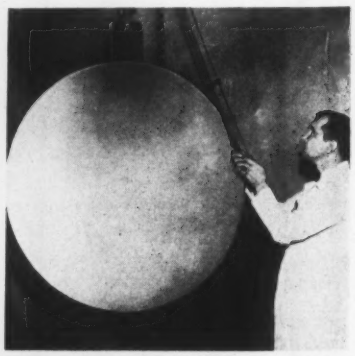
How does it work?

The shift in ferromagnetic behavior below the transition temperature is based on "exchange inversion." Below the transition temperature the exchange interactions between electrons align the magnetic moments of the manganese atoms, canceling them out and producing a nonmagnetic material. Above the transition temperature the magnetic moments are not aligned and a ferromagnetic material results.

Polyethylene Resin Has Good Crack Resistance

Development of a polyethylene molding resin that is said to "set new standards for resistance to environmental stress cracking" has been announced recently by Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo.

The company says the material, called Poly-Eth 4204, has withstood



Easier handling tube sheet—Clad metal tube sheets such as the one shown here are now supplied by Bridgeport Brass Co., 30 Grand St., Bridgeport 2, Conn. with welded-on lifting tabs to minimize handling problems. A 4 by 6 in. long, 1-in. thick tab is welded to the base metal of the tube sheet and drilled to accept a standard ¾-in. clevis pin. After handling is completed, the tab is easily removed by torch or other cutting methods. KEY NO. 617

Corrosion from Reducing Chemicals?

...Test **HAYNES** Alloys

They're not flying saucers. Not space ships. They're down-to-earth test samples of HASTELLOY alloy B to show how stubbornly this material can resist corrosion from aluminum chloride and hydrochloric acid catallysts and other reducing agents.

This stubborn resistance makes alloy B ideal for use in catalytic isomerization and alkylation equipment—equally useful in pharmaceutical operations where even minute contamination is not allowed.

HASTELLOY alloy B is one of 9 HAYNES alloys developed as a result of a continuous program of testing and improving corrosion-resistant alloys for 30 years. Whether oxidizing or reducing conditions are your problem, there's a HAYNES corrosion-resistant alloy to do the job.

Send for test samples

You can tell best by testing. Send us a letter telling us as much as possible about the corrosion involved and we'll be glad to send you free samples for testing under your own plant conditions. Be sure to ask for a copy of the 12-page booklet on HASTELLOY alloy B. Address, 270 Park Avenue, New York 17, N. Y.

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more than 3000 hr of the severest standard stress crack testing. Other polyethylene resins tested under the same conditions failed within 21 hr.

Polymorphous technique used to produce resin

Spencer says the unusual stress crack resistance of the material results from the use of a polymorphous technique to produce a molding grade resin. The polymorphous concept was introduced by Spencer early this year in connection with film-grade resins (see M/DE, Mar '60, p 189). Basically, the process results in a controlled molecular pattern and a balance between the crystalline and noncrystalline elements in the material.

The new molding resin has a density of 0.919 gm per cu cm and a melt index of 1.4. KEY NO. 618

High Strength Alumina Used for Metallizing

A ceramic oxide material for high temperature metallizing applications has been introduced by Gladding, McBean & Co., 2901 Los Feliz Blvd., Los Angeles 39. The material is composed of 95% alumina and selected oxides. It is called Ninety-five.

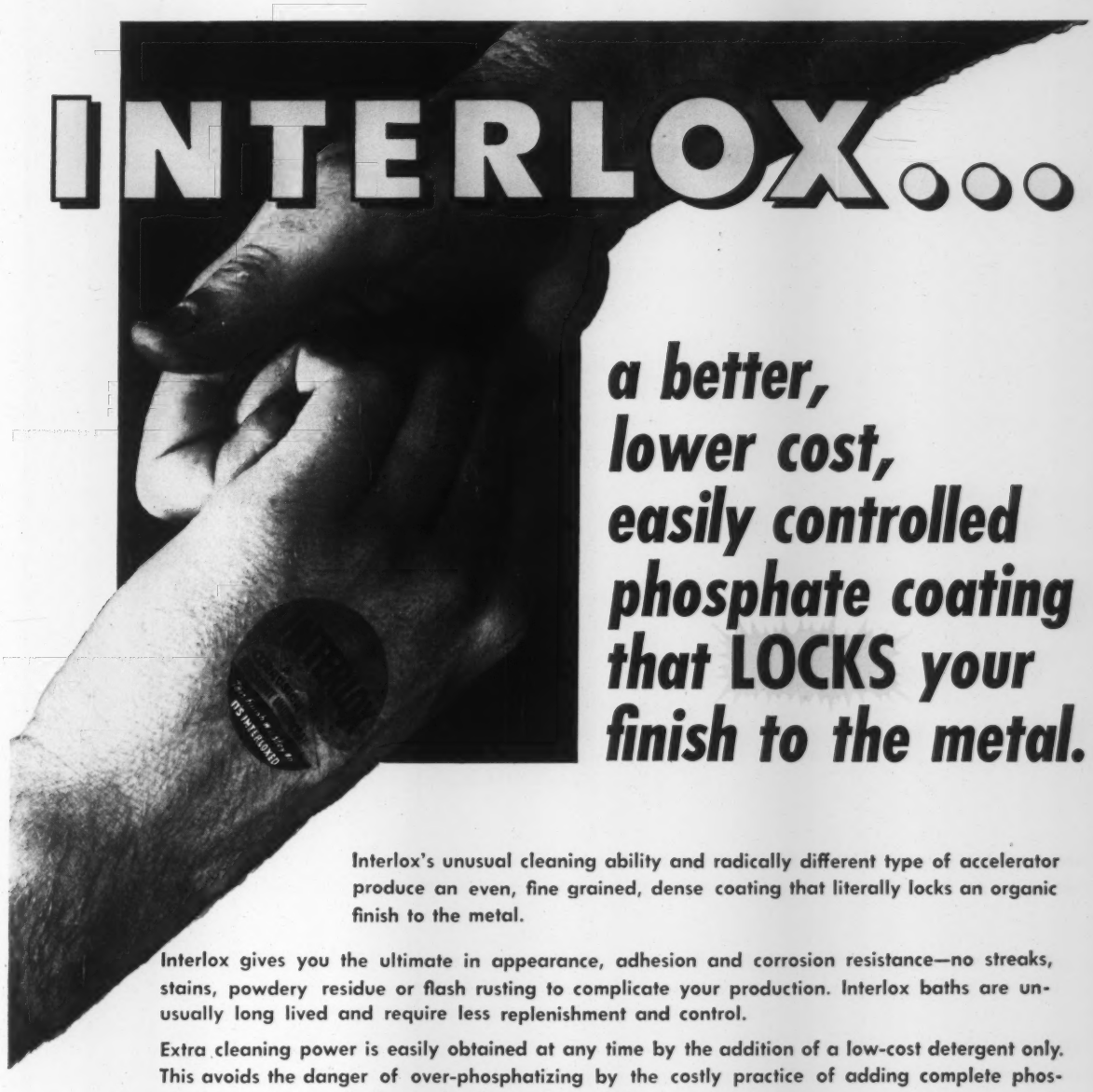
The developer says the new metallizing material insures tight seals, and has high bond strength. It has a compressive strength of 400,000 psi and a flexural strength of 45,000 psi. It can be used at temperatures over 3000 F. KEY NO. 619

Air Hardening Steel Is Strong, Machinable

A new type of air hardening tool steel has been introduced by Darwin & Milner, Inc., 2222 Lakeside Ave., Cleveland 14.

The producer says a carefully controlled addition of minute, uniformly dispersed alloy sulfides imparts superior machinability to the steel without sacrificing mechanical strength. Its impact strength (Izod, unnotched) at Rockwell C62.5 is 104 ft-lb. This value is said to be much

INTERLOX...



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Interlox's unusual cleaning ability and radically different type of accelerator produce an even, fine grained, dense coating that literally locks an organic finish to the metal.

Interlox gives you the ultimate in appearance, adhesion and corrosion resistance—no streaks, stains, powdery residue or flash rusting to complicate your production. Interlox baths are unusually long lived and require less replenishment and control.

Extra cleaning power is easily obtained at any time by the addition of a low-cost detergent only. This avoids the danger of over-phosphatizing by the costly practice of adding complete phosphatizing compound when only cleaner is needed.

There is an Interlox product to meet your particular requirements, whether spray or immersion type, single or multiple stage.

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higher than that obtained for other tool steels with the same hardness.

The steel, called Mineor FM, is suitable for delicate parts where oil hardening steel might distort or crack. It is also suitable for hollow punches on blanking dies, tool holders, and wear resistant machine and die parts. It can be cut to short lengths for sleeves, bushings and guides.

The new steel resists deformation in heat treatment, and hardens at temperatures between 1750 and 1775F to give a Rockwell hardness of C63 to C65.

The material is supplied in the form of hollow bars in sizes from 2¼ to 16¼ in. o.d., and ¾ to 9¾ in. i.d., with wall thicknesses from ¾ to 4½ in. **KEY NO. 620**

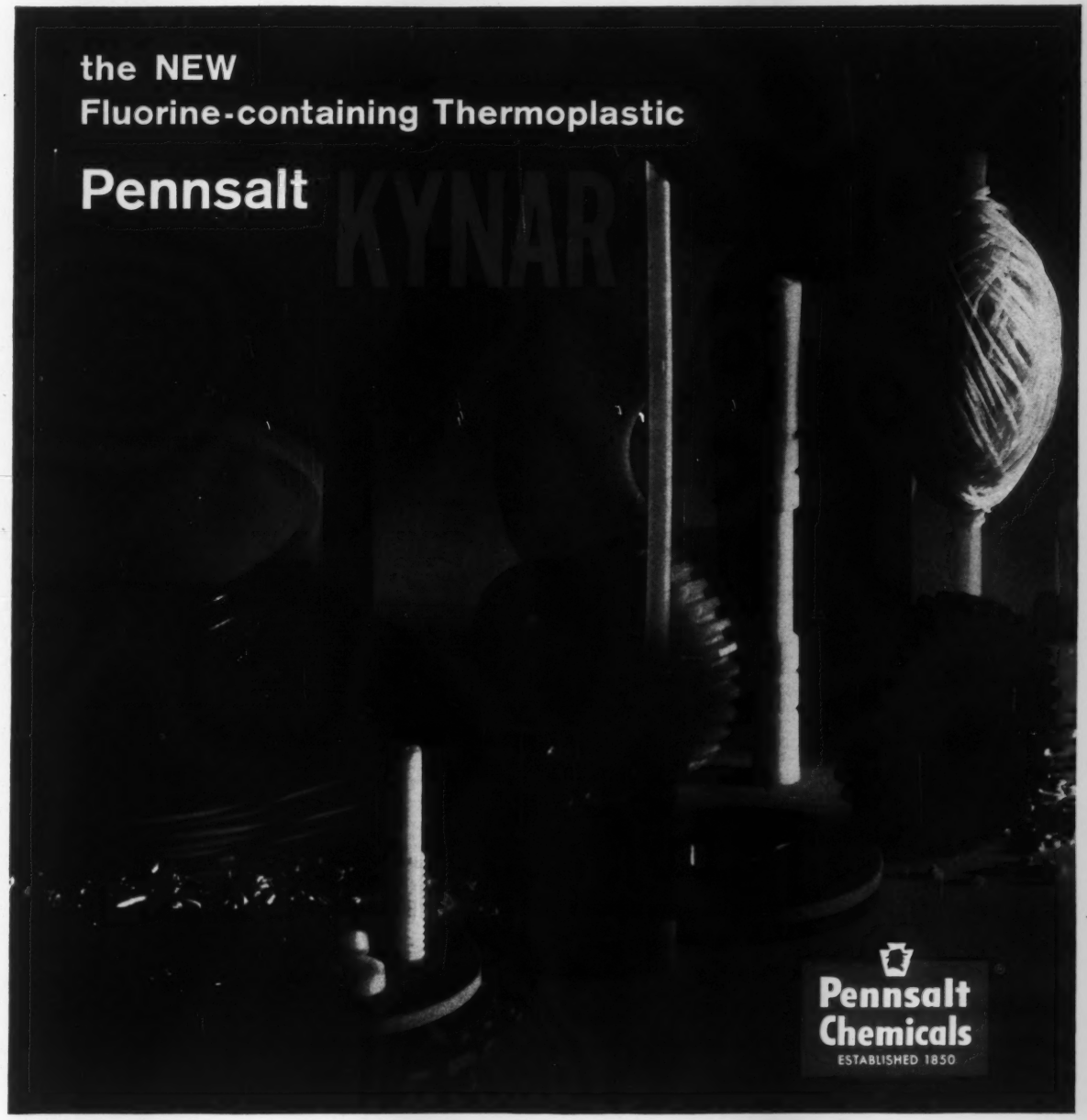
Thin Ceramic Coating Protects Airframes

Research conducted by A. G. Eubanks and D. G. Moore of the National Bureau of Standards for the National Aeronautics and Space Administration has resulted in a new type of ceramic coating in which ceramic oxide powders are bonded with monoaluminum phosphate.

A big advantage of the coating is that it does not require a high firing temperature. Eubanks and Moore say firing at 400 F imparts stability to the coating and provides satisfactory water resistance. They have obtained a good bond to clean sandblasted metal.

The researchers, whose work is described in NASA Rpt. No. D-106, believe that the coating's greatest promise lies in its use as thinly applied layers. They found that an aluminum phosphate coating has good thermal shock resistance when applied in thicknesses of 0.003 in. or less.

The researchers say an aluminum phosphate coating could be formulated to provide high emittance for airframes. A comparable emittance could be achieved on stainless steel and nickel-base alloy airframes by oxidizing the finished airframe at temperatures in the range 1600 to 2000 F. However, such heat treatment is seldom feasible, and the



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**KYNAR is a trade-mark of Pennsalt Chemicals Corp.*

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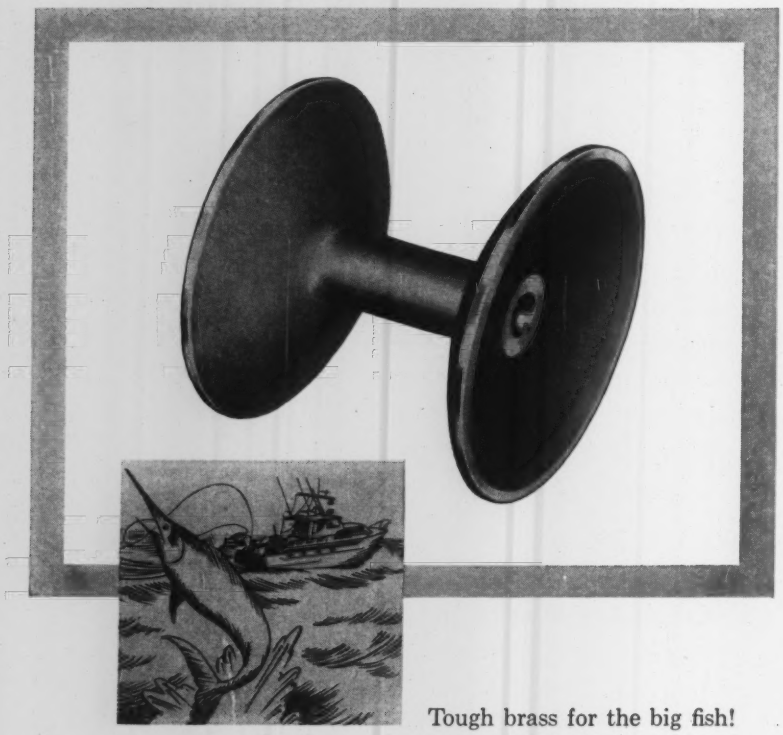
LOOK what brass is doing now!



Tough brass for the big fish!

Here's a *unique* deep-sea fishing reel spool converted to a Titan brass pressure die-casting. Fishermen found that the previous spool of the reel buckled under convulsive pressure of deep-sea marlin and tuna on modern fishing lines.

Stronger, wear-resistant, corrosion-resistant Titan brass die casting solved the problem. In fact, the higher strength of this die casting allows even thinner, streamlined spool sections. And here's the unique part: It's a spool in *one piece!* . . . all because of Titan brass ingenuity.

Like advantages can be yours when you switch to Titan brass pressure die castings. Let us help design and quote on your component parts.

Call your nearest Titan Man for detailed data and a brass die casting quote, or send your sample and blueprint to Bellefonte, Pa., or Newark, Calif., for fast service.

Send for latest folder on Titan Pressure Die Castings Write us on your letterhead.

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achievement of high emittance through the use of a thin ceramic layer requiring heating to only 400 F might be a more practical approach, they say.

The high emittance coating would permit cooler operation of the airframe through radiation of thermal energy.

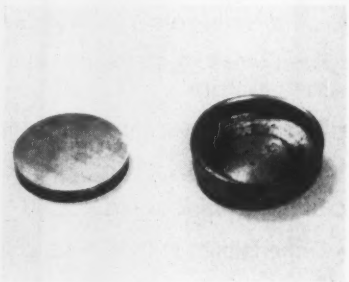
Tungsten Formed by High Energy Process

Tough, ductile and fine-grained tungsten parts are being turned out by the Dynapak high energy rate forming process. The method, described in the July '60 issue of this magazine (p 94), uses a gas-powered ram to form the part. It was developed by Convaair Div. of General Dynamics Corp., San Diego 12, Calif.

How method compares with other forming operations

Tests conducted on high velocity Dynapak extruding and forging machines show that if tungsten is formed quickly, extensive grain refinement occurs, with a striking improvement in ductility. Convair says the Dynapak process is capable of reductions far exceeding those obtainable with conventional tungsten extrusion equipment.

In a series of tests conducted by the National Aeronautics and Space Administration, an 8:1 reduction was the best that could be obtained using a standard extrusion press moving at approximately 150 ipm. And in order to obtain this low level



***Tungsten billet** (left) is easily converted into cup-shaped part by using high energy rate forming process.*

For more information, turn to Reader Service card, circle No. 424

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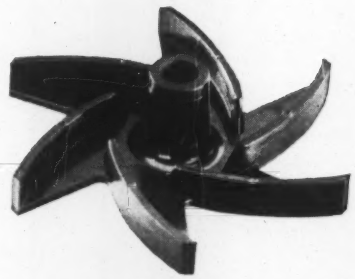
- **Phenolic for pumps**
- **Dip-coating compounds**
- **Plastic process equipment**



FLINT & WALLING MFG. CO., INC.

Why not?

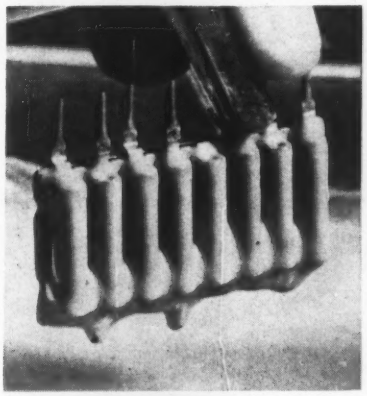
Here's a good way to engineer more profit into a pump.

The impeller is phenolic. It won't rust or corrode; it defies stubbornly the onslaughts of acid, oil, alkali, and soap.

A cubic inch of molded phenolic costs much less than you'd allow for a more traditional impeller material. Forget about machining; phenolic parts seldom need any.

If a pump must handle liquids as hot as 300°F, don't let that stop you from specifying phenolic.

We can work with your molder on the application you have in mind. Why not write us about it? Or simply check the coupon for Bulletin D400. It lists the properties of a typical Durez phenolic molding compound used in pumps, and includes much other useful information.



Coat for components

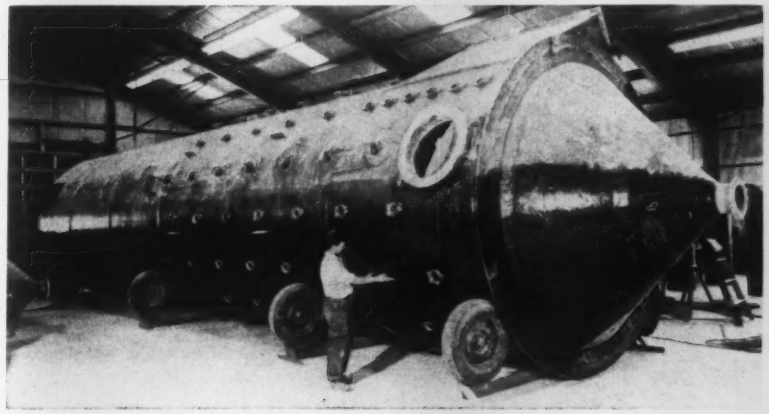
Looking for a simple encapsulating idea? Here's one that works well at heatproofing, moisture-proofing, and preventing shorts in small electrical components. It's non-messy, too.

Dunked in a paste coating, dried, then baked for a short time, components steadfastly resist extremes of heat and moisture that would otherwise raise havoc with their electrical reliability.

Components so coated can be soldered into a circuit without causing the coating to melt or peel. It won't soften, and easily passes a series of −55 to +85°C cycles. One thousand hours at a sweltering 150°C will turn the coating almost black but still won't materially affect the component inside.

The paste is made with Durez phenolic resin-and-filler compounds supplied in powder form. There's a choice of densities and toughnesses. One type is impervious to ketone solvent cements sometimes used in assembling radio and TV chassis.

What can these dip-coating compounds do for you? We'd like to help you find out. Write for more detailed information.



FABRICATOR: DU VERRE, INC., ARCADE, N.Y.

What's your big idea?

Think big. A 50-foot plastic boat . . . a 150-foot plastic radome . . . or a plastic chemical scrubber like this behemoth designed and sold by Buffalo Forge Co.—all are actualities today, with an assist from glass-reinforced Hetron® polyester resin.

The scrubber is expected to save someone a lot of money. In corrosive situations, Hetron has repeatedly proved it can outlast other commonly used materials by a factor of two, three, or more. First cost can be as low as one-third that of other special corrosion-resistant materials.

There's one other important point: safety. Hetron is inherently self-extinguishing. It retards fire because of its unique molecular configuration. Often, a Hetron installation—whether it's ducts, fume hoods, tanks, stacks, or blowers—can obviate the need for a sprinkler system.

If you'd like to know what the process-equipment fabricators are doing nowadays with this versatile, safe polyester, use the coupon. We'll gladly send you a data file on Hetron, including a list of leading fabricators who can shape it to your specifications.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400)
- ☐ "Phenolic Resin Compounds for Dip-Coating"
- ☐ Hetron polyester resin (data file and list of fabricators)
- ☐ "Durez Plastics News" (a review of current plastic applications, mailed bimonthly)

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What's new IN MATERIALS

of reduction, a columbium jacket and a lubricant composed of powdered glass and graphite had to be used. Convair says reductions up to 45:1 can be obtained on tungsten parts by using Dynapak forming, and no cladding or lubricants are required. **KEY NO. 621**

Polystyrene Sheet for Lighting Applications

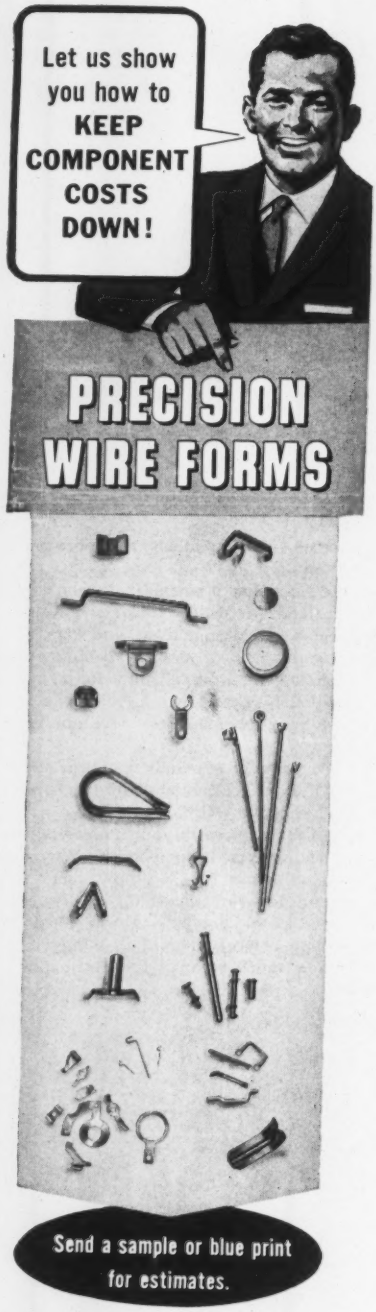
What is claimed to be the first self-extinguishing, medium impact grade of polystyrene sheet for lighting applications has been announced by Sheffield Plastics, Inc., Salisbury Rd., Sheffield, Mass.

Sheet expected to compete with vinyl, acrylic sheets

Designated Frost-White-SE, the styrene sheet is suitable for use in all-plastic ceiling installations, an

Solder-clad metals—Shown here are tiny solder-clad metal stampings designed for use in semiconductor devices for effecting ohmic junctions. The stampings as well as clad metal raw materials are made by Accurate Specialties Co., Inc., 340 Hudson St., Hackensack, N. J. Stampings are supplied in diameters ranging from 0.030 to 2 in. o.d., and in thicknesses from 0.001 to 0.010 in.

The clad metals consist of an overlay of a low melting solder such as tin, tin-antimony or lead-tin-antimony clad on one or both sides of a base material such as nickel, copper, gold or silver. **KEY NO. 622**



Art Wire specializes in wire forms designed for today's automatic production lines . . . manufactured with the precision and uniformity that assure the economy of an uninterrupted work flow. Reduced down-time, and the lower costs made possible by Art Wire's modern production methods mean greater savings to you, and greater profit in your operations.

ART WIRE AND STAMPING CO.
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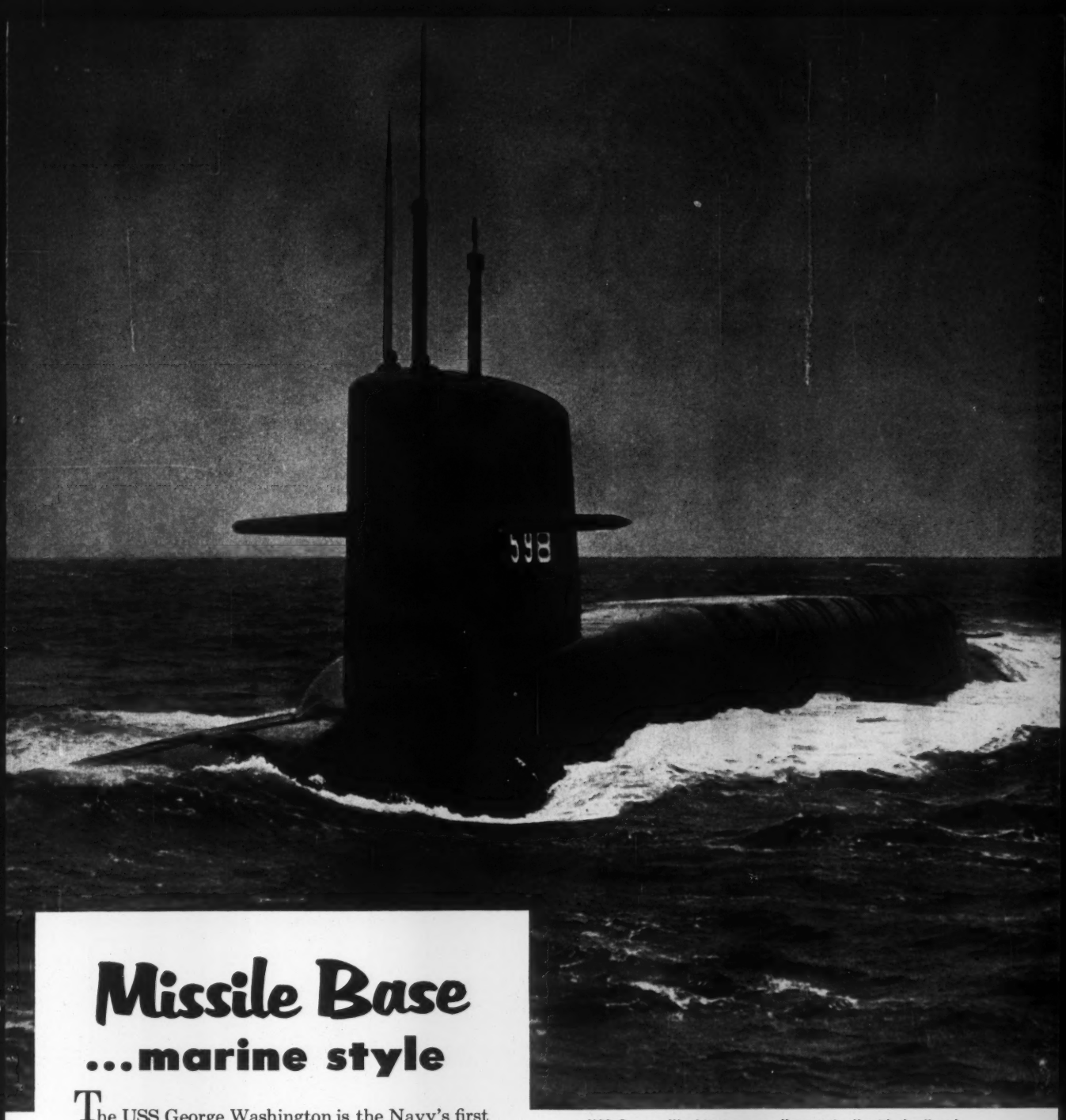
For more information, circle No. 395



Missile Base
...marine style

The USS George Washington is the Navy's first submarine equipped to fire the Polaris missile from submerged positions.

Like the Patrick Henry, Nautilus, Triton, Sea Wolf and other nuclear-powered submarines, the George Washington contains equipment fabricated from stainless steel plate produced by Carlson.

It will be to *your* advantage to specify Carlson stainless steel plate and plate products. Our specialists produce exactly what you want and deliver it to you on schedule. Contact Carlson now.

USS George Washington now "on station" with the fleet!
OFFICIAL U.S. NAVY PHOTO

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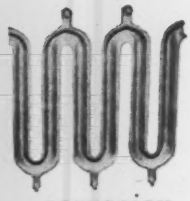
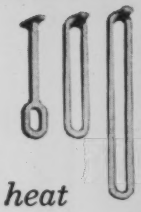
SHELL MOLDED PARTS



corrosion resistant



heat resistant

abrasion resistant

DURASHEL

- *accuracy*
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We are equipped to help you pick the right alloy for planned service conditions...We are equipped to help you design your part to take advantage of the possibilities of shell molding...We are equipped to manufacture high alloy, shell molded parts to your specifications in quantity and on time!

We suggest you check on shell molding for your high alloy casting requirements. Write us today for additional information.

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CHICAGO OFFICE: 332 South Michigan Avenue

DETROIT OFFICE: 23908 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 412

application presently restricted almost exclusively to vinyl sheet. Color stability and light transmission characteristics are said to be superior to those of vinyl sheet. For example, under fluoroscent lamps the styrene sheet is color stable up to 50,000 lighting hours; in contrast, vinyl sheet discolors quite rapidly.

Break resistance is comparable to that of vinyl and better than that of acrylic. Large sections of the new sheet can be bent or twisted during installation without shattering as regular styrene or acrylic would.

Flame resistance

To demonstrate the self-extinguishing characteristic of the styrene sheet, sample strips 12 in. long were held in a vertical position and ignited at the lower end, as required by ASTM D568-56T. The flame went out before consuming 2 in. of the strips, well under the 8 in. permitted by the test. **KEY NO. 623**

Permanent Magnet For Core-Type Meters

A new permanent magnet material has been designed for use in equipment that is subjected to extreme demagnetization forces. It is especially useful in magnetic core-type meters because it eliminates the problem of aligning orientation direction.

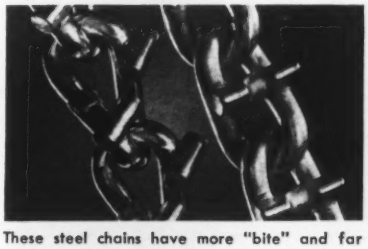
Also, non-oriented core magnets provide a more linear and accurate scale in the meter than oriented core magnets.

The material, called Alnico VII-S, is the newest addition to a group of

PROPERTIES OF ALNICO VII-S

Condition →	Oriented	Non-Oriented
Residual Induction (B_r), gausses	8570	7540
Coercive Force (H_c), oersteds	1040	890
Max Energy Product (B_dH_d)	3.7×10^6	2.5×10^6
Peak Magnetizing Force, oersteds	3000	3000
Max Permeance Coefficient at B_dH_d	8.0	8.5

You can't beat steel chains for non-skid stops and starts



These steel chains have more "bite" and far out-last ordinary chains. Only after the hardened steel "lugs" or "bars" are worn down do the links begin to show wear.

Tires need the strong "bite" of steel for safe stops and sure starts both on slippery ice and snow. And steel chains have extra "bite" when they are reinforced with hardened steel lugs or bars welded on each cross-link. They last longer, too. Leading chain manufacturers rely on steel from Bethlehem.

Bethlehem makes nearly every grade of steel wire . . . for bird cages, upholstery springs, cold-headed products, woven-wire cloth, and welded products . . . to name just a few. Whether you need a special-purpose wire, a coated wire, or a general-purpose grade . . . you can call on Bethlehem for technical aid from experienced engineers. Simply get in touch with the nearest Bethlehem sales office or write to us at Bethlehem, Pa.

Steel for Strength
. . . Economy
. . . Versatility

Bethlehem Steel Company, Bethlehem, Pa. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 419

Chace THERMOSTATIC BIMETAL Actuates Another Precision Product...

Here's a fine product which adds to the comfort and safety of the home. There's a secure feeling developed when—after having been away from home all day—you come home in darkness to find a brightly-lighted house waiting for you. No stumbling and fumbling in the dark either, thanks to PROTECT-O-LITE made by Energy Kontrols, Incorporated. This thermal switch photo electric eye turns on the light at dusk, turns it off at dawn. The absence or presence of light causes the electric eye to energize or degenerize a resistor, causing the working bimetal to bend and actuate the control switch. A time delay eliminates false operation due to momentary flashes of light or temporary cloud movements. The PROTECT-O-LITE is not a photorelay . . . Chace Thermostatic Bimetal serves as the actuator, doing two jobs: it drives the switch as well as providing the time delay. The PROTECT-O-LITE is temperature compensated over a range of −25°F to +150°F. The ambient compensator, also made of Chace Thermostatic Bimetal, assures dependable operation of PROTECT-O-LITE at any temperature.

Like many other respected companies, Energy Kontrols assures the extreme dependability of its products. The dependability of PROTECT-O-LITE is greatly affected by two small pieces of Chace Thermostatic Bimetal. But this is a familiar responsibility at Chace. In more than a third of a century of specializing in thermostatic bimetal, Chace has become recognized for the utter dependability of its only product: precision thermostatic bimetal.

SEND NOW FOR OUR NEW "INFORMATION BOOKLET!" It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal. More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 392

dispersion-hardened alloys consisting basically of aluminum, nickel and iron, with some cobalt, copper or titanium added. It is available from Indiana Steel Products Div., Indiana General Corp., Valparaiso, Ind.

Alnico VII-S is ranked as one of the more brittle Alnicos. Therefore, it is necessary to cast the material to the desired shape or to nearly finished tolerances, leaving only grinding operations to achieve required tolerances. For greatest economy, the producer says cast Alnico magnets should have tolerances as large as possible, using the as-cast tolerances whenever possible to avoid grinding.

Since Alnico VII-S can be supplied either oriented or non-oriented, it is important that this condition be specified. **KEY NO. 624**

Teflon-FEP Film Bonded with Adhesives

A cementable FEP fluorocarbon film has been introduced by E. I. du Pont de Nemours & Co., Inc., Film Dept., Wilmington 98, Del.

FEP and other fluorocarbon plastics usually have to be heat sealed to other materials, or made receptive to adhesives by treating with alkali metals or radiation (M/DE, Apr '59, p 146).

Du Pont does not say how the film has been made bondable. But development work to date indicates that the new FEP film can be bonded with many standard adhesives to a variety of engineering materials.

The cementable FEP film is currently being offered in developmental quantities in widths up to 30 in. and in gages from 1 to 40 mils.

Potential applications

The film can be bonded with epoxy adhesives and used as a liner for glass filament-wound chemical and cryogenic fuel tanks and cylinders,

PROPERTIES of most engineering materials can be found in the fourth edition of M/DE's *Materials Selector* reference issue, published in November. Names and addresses of suppliers are also listed.

R/M ASBESTOS-PHENOLICS

the plastics that come back from outer space

When you think of reinforced plastics for high-temperature parts, think first of R/M asbestos-phenolics.

These advanced space-age plastics put you ahead in every important physical property—high strength-to-weight ratio, heat resistance, shock resistance, low thermal conductivity and diffusivity, and controlled ablation.

R/M asbestos-phenolics are available as felts, mats, molding compounds, and as molded rods and tubes for your prototype work. Delivery is prompt. And this complete line is backed by comprehensive technical data and know-how.

Bring your thermal protection problem to R/M for a time-saving solution at lower cost.

Nose cone molded of R/M Style 42RPD Pyrotex® mat.

RAYBESTOS-MANHATTAN, INC.

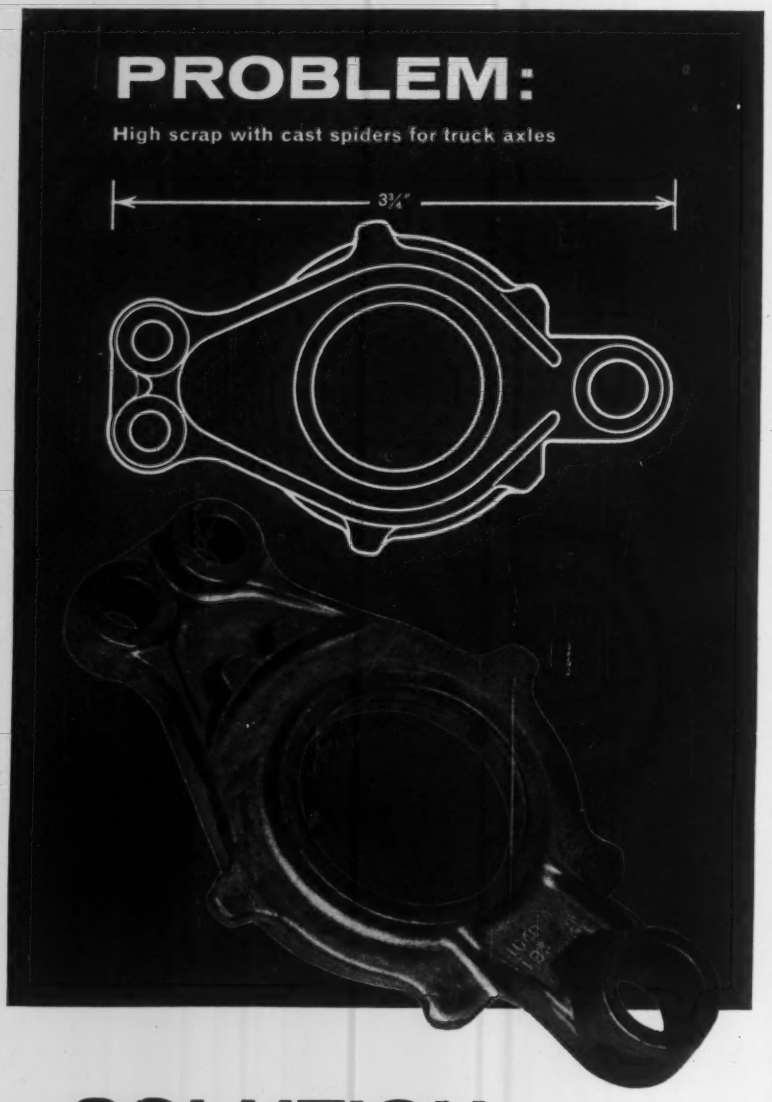
Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 381

PROBLEM:

High scrap with cast spiders for truck axles



SOLUTION:

Amforge changed the design to accommodate *forging* techniques instead, using lock dies. Some bosses were coined.

There was less scrap. Less machining was required. A lighter, stronger piece resulted—highly important in the weight-conscious trucking industry.

If you happen to have a similar problem part, consult AmForge. Write for our new brochure or the name of your AmForge Sales Engineer.

Remember: *your problems . . . our challenge!*

AM FORGE

a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California.

WHEN IT'S A VITAL PART, DESIGN IT TO BE FORGED

For more information, turn to Reader Service card, circle No. 333

as an ice release coating on aluminum ice cube trays, and as a release cladding on heated or chilled processing rolls.

The film can also be bonded with rubber adhesives and used as a liner for rubber and fabric hose, and over rubber and asbestos for chemical resistant diaphragms and seals.

KEY NO. 625

High Nickel Alloy Sold as Sheet, Bars

Rolled Alloys, Inc., 5309 Concord Ave., Detroit 11, is supplying sheets, plates and round bars made of a high nickel alloy called Raonel. Conforming to ASTM B168-58T and B166-58T, it contains 72 min nickel, 14 to 17 chromium, 6 to 10 iron, 1 max manganese, 0.15 max silicon and 0.015% max sulfur.

Previously, the company says, only one other producer made an alloy conforming to the two ASTM specifications.

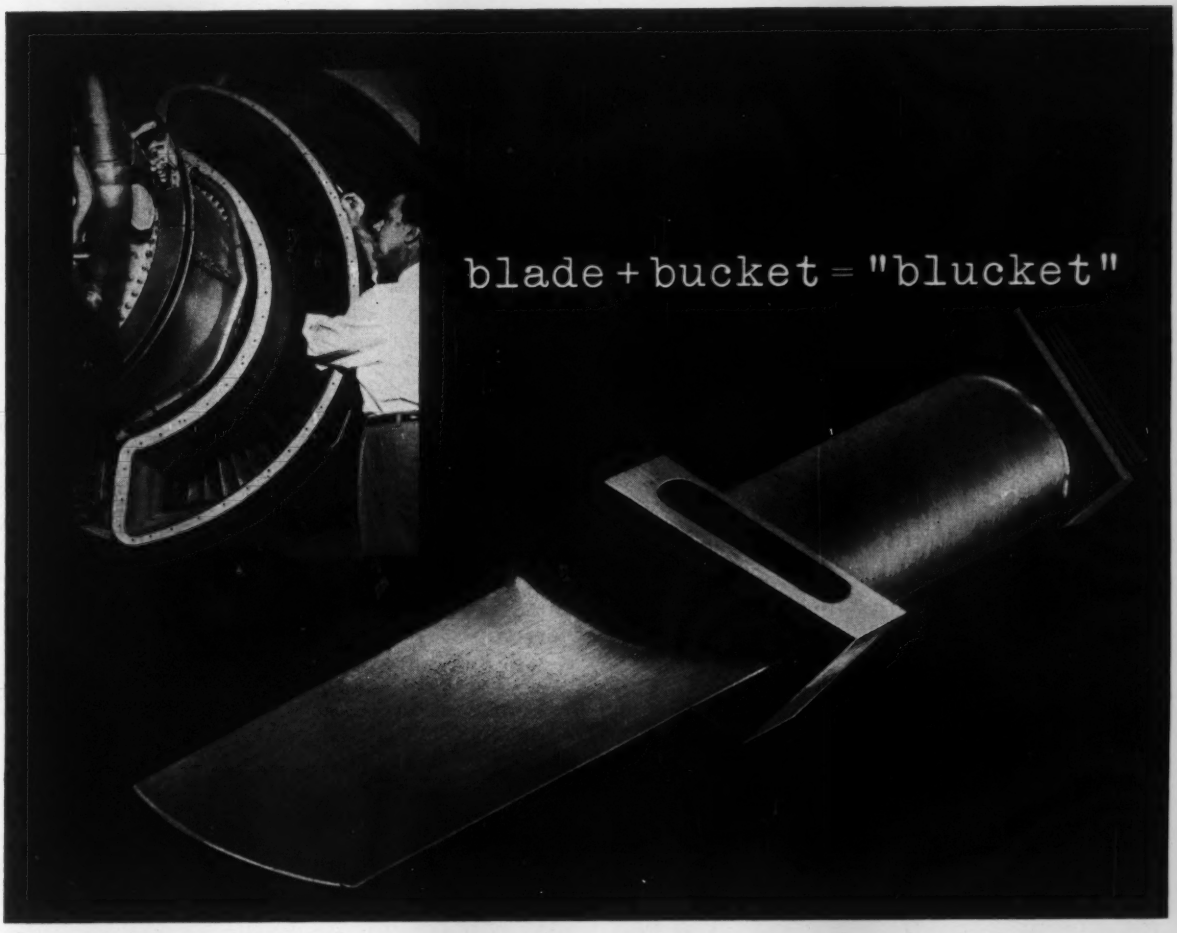
Sheets of the new alloy are available in sizes of 36 by 120 in. and 48 by 120 in. in thicknesses from 1/16 in. Plates are available in sizes of 72 by 120 in. in thicknesses through ½ in. KEY NO. 626

Flexible Magnetic Tape

A flexible magnetic tape for a variety of consumer and industrial applications is currently available from Applied Magnetics Corp., 194 River Rd., Leeds, Mass.

The product, called Magnyl, is a vinyl tape containing finely divided magnetized particles. One side exerts a strong magnetic attraction over its entire surface; the other side is nonmagnetic. The nonmagnetic side can be molded, embossed, hot stamped, printed, silk-screened or laminated with printed or unprinted metal foils, plastics films and papers. It can be cut with scissors or a die.

The producer says the magnetic tape can be used as a seal for refrigerator and freezer doors, as a masking material, and as trademark



new design in *Carpenter* high temperature alloy V-57

Everything about this combination fan blade-turbine bucket is new except its predictable performance . . . a built-in characteristic of all Carpenter high temperature alloys.

V-57 is the super alloy now used to forge this unique new jet engine component. V-57 replaced A-286 (originally used) because of its superior mechanical properties at operating temperatures. Like all Carpenter vacuum melted metals, V-57 is produced with exclusive Carpenter quality controls that permit tighter forging tolerances, better machinability and improved cold forming properties.

Carpenter's VACUMELTROL® (induction vacuum) and CONSUMET® (consumable electrode) melting processes assure you more accurate forgings with better finishes, fewer rejects, faster production . . . and, most important . . . true predictable performance in your high temperature alloy components. Ask your Carpenter Representative for details.

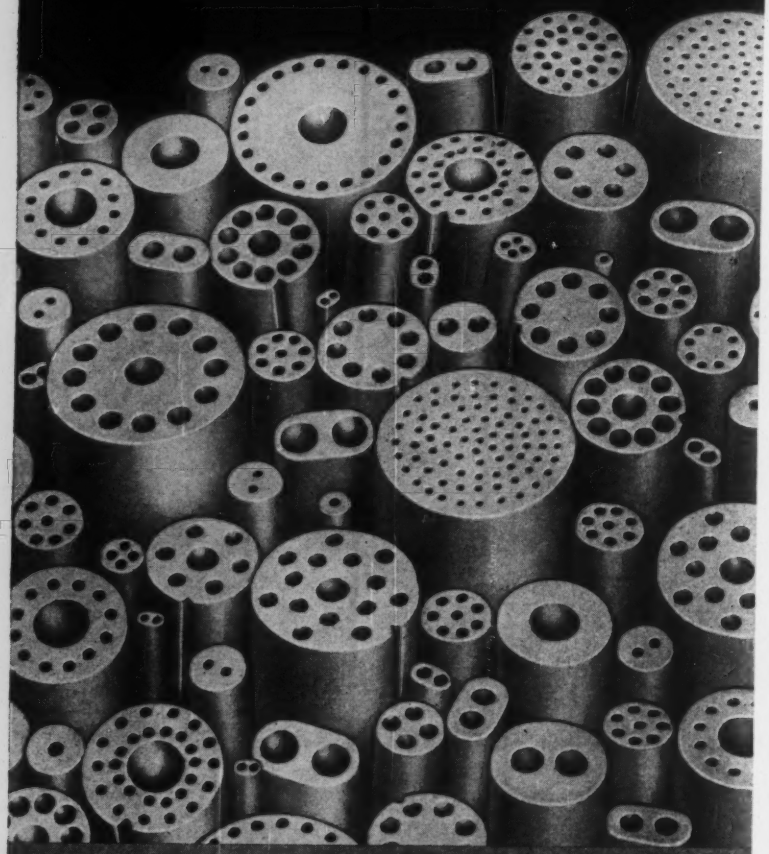
Carpenter steel

you can do it ***consistently*** better with Carpenter Specialty Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 421

HIGH TEMPERATURE! ALUMINA OR MULLITE



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High-temperature ceramic insulators! Sizes .020 and larger! 1-inch, 2-inch and 3-inch lengths! Special sizes, shapes and lengths and multiple bore quickly available.

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REFRACTORY PORCELAIN COMPANY

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For more information, turn to Reader Service card, circle No. 405

plaques and other advertising devices. It can also be used with die-cut letters and figures for displaying prices on products made of steel, such as automobiles and appliances.

The tape is dark brown in color and is supplied in widths from 5/16 to 2 in., and in thicknesses from 1/16 to 1/4 in. Prices range from 75¢ per sq ft on orders from 1 to 99 ft to 28¢ per sq ft on orders over 20,000 ft. **KEY NO. 627**

Vulcanized Fibre Is Flame Resistant

A new electrical grade of flame resistant vulcanized fibre is designed for use in data processing equipment, business machines, radios, television sets and appliances.

The material, designated Pyronil E and available from National Vulcanized Fibre Co., 1060 Beech St., Wilmington, Del., is rated nonburning under ASTM procedures D635 and D568.

It is supplied in rolls, coils and sheets in thicknesses ranging from 0.010 to 1/16 in. A 48 by 80-in. sheet of the material 1/32 in. thick sells for $3.30. **KEY NO. 628**

Bonded Graphite Is Strong, Wear Resistant

Improved nonmetallic bearings are promised with the development of iron-bonded graphite materials that are said to combine the strength of iron with the antifriction properties of graphite.

The new materials were developed by the Engineering and Research Dept. of Ford Motor Co., Dearborn, Mich. They were described by Dr. Michael Humenik, Jr. at the National Metal Congress, held last fall in Philadelphia.

The iron-bonded graphite materials are made by conventional powder metallurgy techniques.

Calcium-silicon alloy key to good compacts

Previous attempts to combine graphite with iron by powder metallurgy techniques always resulted in

PRECISE TUBING HELPS HANDLE HOT STUFF

Juggling radioactive materials takes a pair of sure hands—sure mechanical hands. Malfunctions cannot be tolerated. All components must adhere to rigid specifications and operate together perfectly. A good application for precise tubing.

We make stainless steel and nickel tubing in mechanical, aircraft, capillary and hypodermic grades in sizes up to 1 inch OD—plus an amazing variety of "specialties" such as super and "exotic" alloys, glass-to-metal sealing alloys and clad metals.

In addition, we produce a vast line of platinum products and chemicals that have been used by industry for over a century.

We are unique because of our ability to *work these metals to such tiny, precise forms.* Bulletin No. 12 describes our tubular products—Catalog No. 5 describes our platinum products. Write for them.

BISHOP

Tubular Products Division **J. BISHOP & CO.** *platinum works* 40 KING STREET, MALVERN, PENNA.

A JOHNSON MATTHEY ASSOCIATE "METALS FOR PRECISION AND PERFORMANCE"

For more information, turn to Reader Service card, circle No. 375

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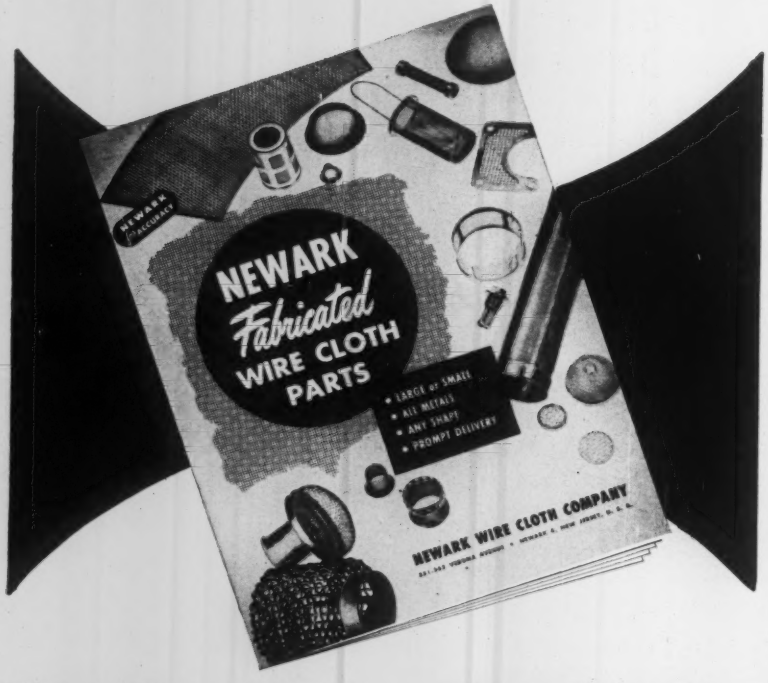

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Money saving ideas and design suggestions on Fabricated Wire Cloth Parts. Strainers, filters, inserts... in any metal, all meshes, to your specifications. Large or small runs. Simple or complex parts. Special metals such as "Inconel", "Monel", "Nichrome" and stainless steel.

Our engineering service includes not only a thorough analysis of your parts, but also a careful study as to the type of cloth best suited to your needs.

Newark Wire Cloth Company

351 Verona Avenue • Newark 4, New Jersey

For more information, turn to Reader Service card, circle No. 384

products with poor strength and extremely brittle characteristics because of the poor compatibility of liquid metals and graphite. But Humenik says this problem has been overcome in the Ford process by adding a powdered calcium-silicon alloy to the mixture during liquid-phase sintering. The result, says Humenik, is a material that combines the best properties of iron and graphite.

So far nickel, cobalt, copper, silver and aluminum-graphite combinations have also been made successfully. Compositions have been prepared that range from 40 to 90% graphite by volume.

Graphite-rich vs metal-rich compositions

A series of tests showed that graphite-rich compositions had superior strength properties compared to pure graphite materials. The graphite-rich compositions are expected to be used for dry bearing applications.

Other tests showed that metal-rich compositions had strength properties that compared favorably with the best strengths obtained in metal powder parts used for externally lubricated bearing applications.

Corrugated Vinyl Sheet

Translucent corrugated vinyl sheeting made from a new rigid compound is designed especially for structural glazing and internal partitioning applications.

The vinyl compound is called Geon 82304 and is a new product of B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15. According to Goodrich, the compound is self-extinguishing, and has high structural strength and excellent weather resistance.

The sheeting is made by a new continuous sheet extruding and corrugating process developed by National Rubber Machinery Co., Akron, Ohio. Translucent sheeting is extruded using a 52-in. wide sheet die and a newly developed post-corrugating form positioned in tandem with the extrusion die.

Development of the new method, together with the new vinyl com-

Steel

for Strength
. . . Economy
. . . Versatility

Casting... or Forging?

From the look of it, most people would probably guess casting. But it's a forging. Which proves a point. Many parts *look* too complicated for forging, but actually aren't. By careful selection of parting line, close trimming, and punch-outs, we're often able to forge parts you'd never expect to obtain as forgings. If you have such a part (and would welcome the strength and economy of forgings), send us a finished print. We'll be glad to study it and tell you frankly whether or not we can forge it. If we can, you can count on us for fast delivery.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 358

Two Hardness Testers in a Single Instrument

Wilson "Rockwell" TwinTester

• The new Wilson Rockwell TwinTester combines in one instrument the functions of both a Rockwell and a Rockwell superficial hardness tester. Designed primarily for use in such areas as tool departments, maintenance repair shops and laboratories, the TwinTester offers many outstanding features.

Large direct-reading dial is marked with B and C scales for Rockwell hardness, and N and T scales for superficial Rockwell hardness readings. Just one zero set position for all scales.

Easy to operate, the TwinTester can be changed from Rockwell to Rockwell superficial testing in seconds.

Complete equipment includes cowl, ball penetrator for B and T scales, Rockwell test blocks, anvils, dust cover and protective sleeve set.

A complete line of Wilson Rockwell instruments is available, including semi and fully automatic models.

Wilson "Brale" Diamond Penetrators Each diamond is cut to an exact shape. A comparator check and microscopic inspection of each diamond assure perfect readings every time.

Write for details—Ask for Catalog RT-58. It gives complete information on the Superficial tester as well as on the full line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

ACCO

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-E Park Avenue, New York 17, New York

For more information, turn to Reader Service card, circle No. 371

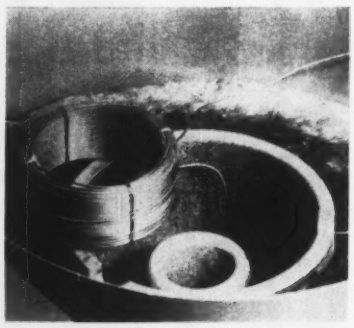
pound, is said to make vinyl sheeting competitive for the first time with other types of corrugated plastics sheeting for architectural applications. KEY NO. 629

Photoemissive Coating for High Temperatures

A new photoemissive material has been developed for high temperature electronic applications. The material, a compound of antimony, potassium and sodium, is deposited as a thin, semitransparent coating on glass. Light striking the coating causes it to release electrons which generate an electrical signal.

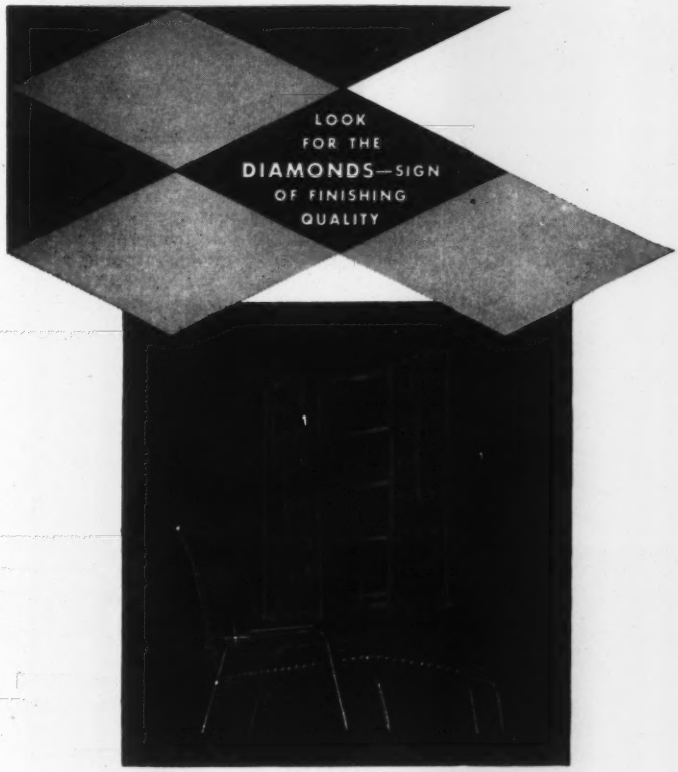
Developed by Westinghouse Electric Co., Box 2278, Pittsburgh 30 under a research contract with the Navy's Bureau of Ships, the new material is expected to be used in such devices as imaging and photomultiplier tubes in which photosurfaces convert radiant energy into electrical energy.

Westinghouse says the new ma-



Gas chromatography tubing—Superior Tube Co., 1548 Germantown Ave., Norristown, Pa. has introduced a new line of annealed stainless steel tubing designed especially for gas chromatography. Heretofore, glass, copper and plastics have been used for gas chromatography tubing.

The gas chromatography technique is used to isolate components from complex gaseous and liquid mixtures by passing them through small tubular columns (such as that shown here) which are coated on the inside with a liquid or packed with a solid for selective adsorption. KEY NO. 630



NOW—A Great New Combination for

DOUBLE PROTECTION

Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast. easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life protection from handling, and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.

Allied Research Products, Inc. 4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
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IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

For more information, turn to Reader Service card, circle No. 414

are small precision metal parts ruining your appetite?

Do you look at the Chef's Special and see only small precision metal parts? Does your caviar taste like old production orders? What you're suffering from is small component indigestion . . . and Torrington is the specialist to cure it.

Manufacturing special metal parts is a full-scale business with us. We're geared to turn out whatever you need with the precision, finish, temper and hardness you need . . . turn it out at high speed at a cost surprisingly lower. We have the specialized skill and engineering experience to handle the job from start to finish.

If *you* need special parts in large quantities, don't decide anything until you've called us. Better still, send us a blueprint of the part you want. Our estimate will be prompt and accurate.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Connecticut

For more information, turn to Reader Service card, circle No. 425

terial will permit operation of these photosurfaces at temperatures well above 140 F, a temperature at which the operating life of conventional materials has generally been inadequate.

Metal-Filled Silicone Is Radiation Barrier

Development of a new family of silicone rubbers that are reinforced with finely divided and uniformly dispersed metal particles was disclosed recently by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

The materials, designated Cohrlastic HG, are said to have good resistance to weather, ozone and ultraviolet light. They also have good electrical resistance (10^{17} ohm-cm), and can be used over the temperature range -85 to 500 F.

Because of the combination of metal and silicone rubber, the developer believes the material might be used as a shielding against high energy radiation or as an acoustic damping material.

The new product can be processed in the same manner as conventional silicone rubber compounds.

KEY NO. 631

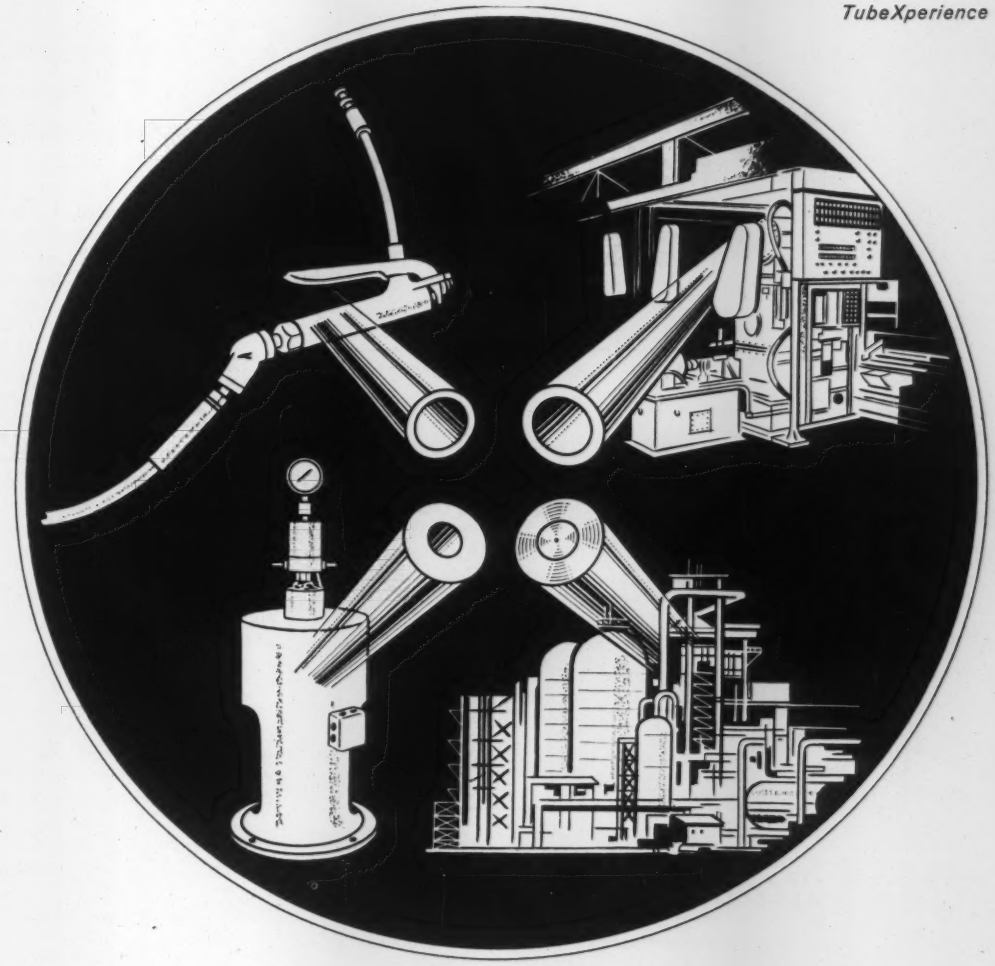
Urethane Foam Cuts Refrigeration Insulation

The high thermal efficiency of a new type of foamed-in-place urethane insulation permits insulation and wall thicknesses of conventional refrigerated equipment to be cut almost in half.

The material, called Expandoform, is a two-part, polyether-type urethane available from Armstrong Cork Co., Insulation Div., Lancaster, Pa. It expands to a density of 2 lb per cu ft at room temperature, and cures in 24 hr to a stable rigid foam.

The foam supports any load normally encountered in conventional refrigerated equipment without reinforcement by framing or load bearing members.

The material is odorless, resistant



Superior tubing makes pressures behave

whether 125, 5000, 30,000 or 100,000 psi

Superior small-diameter tubing makes pressures behave whether low, medium, high or super. Superior pressure tubing can be roughly divided into two groups: commercial pressure tubing for use in a range up to 20,000 psi; premium super pressure tubing to handle pressures from 15,000 to 100,000 psi. Both ranges can be handled effectively by a number of different analyses, depending on service requirements. Typical applications for Superior general-purpose pressure tubing include pressure tools, machine tools, heat exchangers and condensers. Superior super-pressure tubing is found in hydrogenation process equipment, high-pressure autoclaves, and pilot plant installations in chemical and oil refining plants.

All Superior pressure tubing offers many advantages. It helps prevent critical failures and downtime. It assures long service life, high fatigue strength, excellent corrosion and chemical resistance. In the range from 15,000 to 100,000 psi, Superior super-pressure tubing is a premium product. It is produced from specially selected raw materials. Inside surfaces are conditioned to remove fissures and other defects. During processing, special degreasing operations are performed, and the inside diameters are conditioned to insure a clear, smooth surface. Two types are available: a single wall mechanical tubing and a double wall, or composite unit, made from two thinner tubes. It is produced in an annealed condition and in ⅛ hard temper, and to mechanical properties specified by the customer. All Superior pressure tubing is 100% hydrostatically tested to recommended working pressures, and rigidly inspected for defects.

We can probably help you with any tubing problem that may confront you . . . in pressure, super-pressure or other applications. Contact us and feel no obligation. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

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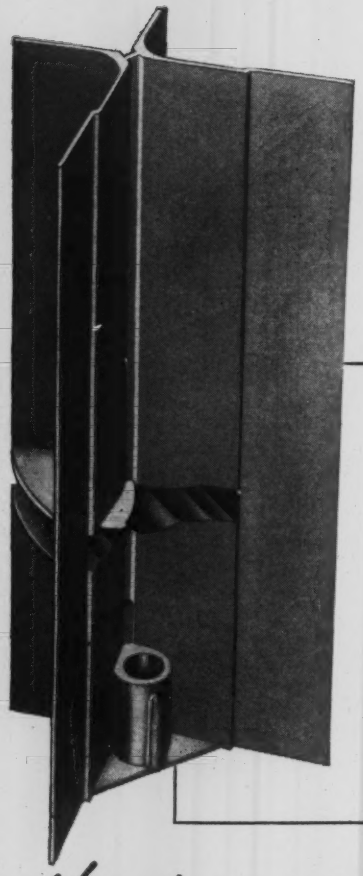
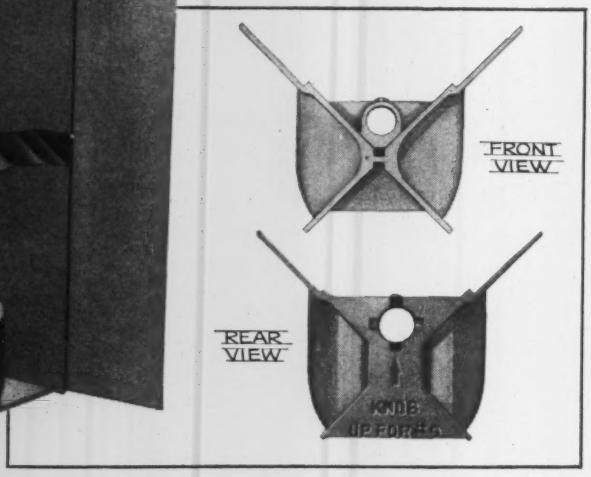


Die casting made this design possible



Here's a switch!

Product design usually dictates which production process will best produce the part. This is a case in reverse . . . where the process influenced the design.

Most important, this customer knew production. He knew that only die casting could hold the tolerances, maintain the uniformity, meet the unit cost requirements, and still produce at the necessary speed.

What did he do? He brought his partly completed design to Twin City Die Castings Company. When Twin City cleared the part for die casting, the customer completed the design.

Then Twin City went beyond. Expected costs were slashed when Twin City used hinged cores.

The customer saved money because he knew production requirements and allowed die casting to do the maximum job for him. Twin City Die Castings knew how to make the process perform for the customer.

Twin City's ability to make die casting help solve design problems has proved a service extra for hundreds of customers. When you design for die casting write, wire or phone Twin City Die Castings Company. Chances are, a Twin City engineer can make die casting solve design problems for you.

...only DIE CASTING can
✓ cut your costs ✓ offer such flexibility
✓ provide such accuracy

Leading Die Casters in the Upper Midwest

TWIN CITY DIE CASTINGS CO.

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For more information, turn to Reader Service card, circle No. 427

to fungus and bacteria, has good adhesion properties, has no corrosive effect on metals, and is resistant to water, alcohol, and petroleum-base solvents and oils. **KEY NO. 632**

Coatings Made of Low Cost Resins

New data have recently been released by Enjay Chemical Co., Div. of Humble Oil & Refining Co., 15 W. 51st St., New York 19 on a line of thermosetting plastics resins called Buton. The resins are based on butadiene-styrene polymers and are designed for use in decorative and protective coatings.

A big advantage of coatings based on Buton resins is that they can be flame-cured in the field in a few seconds. And flame-curing is said to enhance the properties of Buton resins rather than degrade them as is the case with other resins.

Although price has not been disclosed, Enjay says Buton resins are lower in cost than most other quality resins.

The resins, formerly called C-Oil and Butoxy, were first announced in the spring of '59 (M/DE, Apr '59, p 136) and went into commercial production last fall (M/DE, Nov '60, p 25). They are presently supplied in three grades:

Buton 100 is an all-hydrocarbon copolymer with a molecular weight of approximately 8,000 to 10,000 and a high degree of unsaturation (iodine number, 300). The resin is a viscous, clear, almost colorless liquid. It is supplied in a solvent-free state, and is readily soluble in all hydrocarbon thinners, chlorinated hydrocarbons and selected oxygen-containing solvents such as methyl ethyl ketone.

Buton 200 and Buton 300 are prepared by chemically modifying Buton

LOST BYLINE

We regret that the name of author D. C. Ludwigson, Battelle Memorial Institute, was inadvertently dropped from the article on "Which Heat Treatment for AM350 and AM355" on p 110 of our December issue.

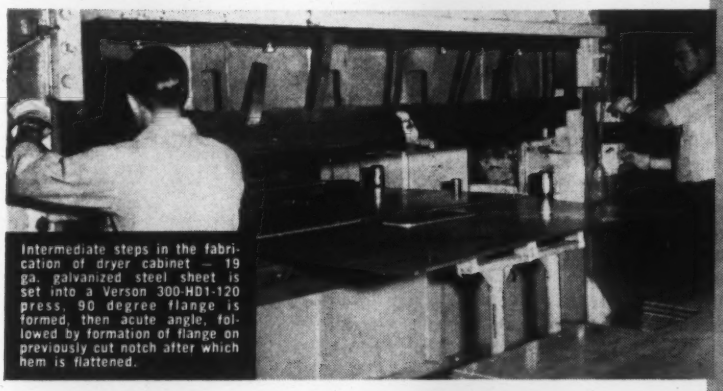
ZINC COATED STEEL

Is The Proven Answer To These

Corrosion Resistance + Formability Make Continuous Galvanized Sheet The *Most Practical Material* For Both Painted and Unpainted Washer and Dryer Parts.

MAYTAG protects product quality and profits by using 15,000 tons of continuously galvanized steel per year for washer and dryer parts.

After extensive tests, Maytag engineers decided that galvanized steel gave them the most practical combination of strength, excellent corrosion resistance and ductility for low cost fabrication. This zinc-coated material is used on both painted and unpainted parts to provide lasting protection against the combined corrosive effects of water, heat, humidity, soaps, detergents, bleaches, abrasion and aeration.

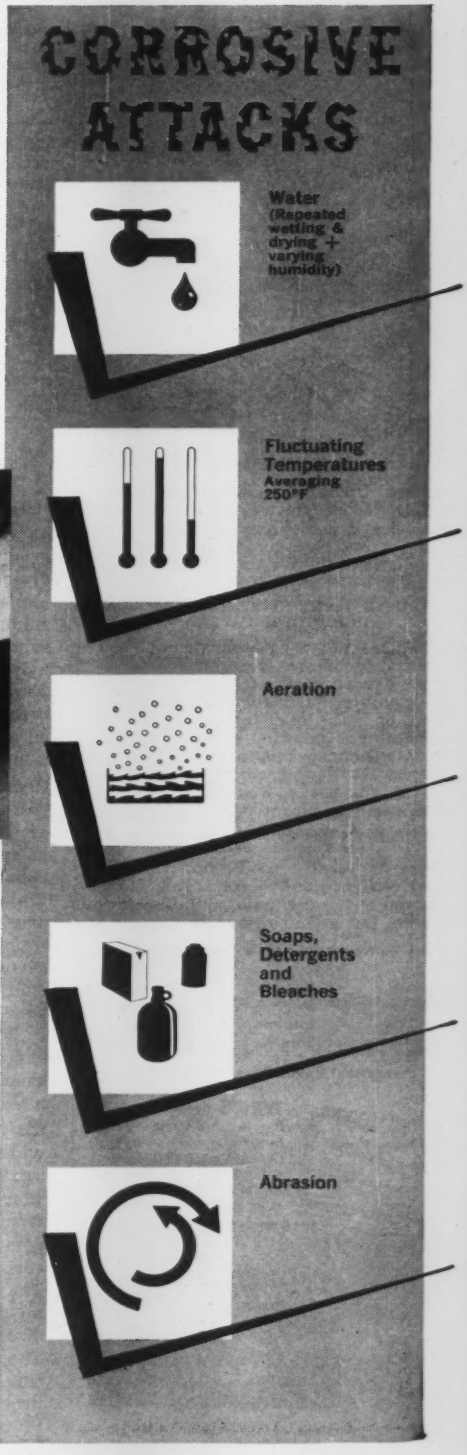


Intermediate steps in the fabrication of dryer cabinet — 19 ga. galvanized steel sheet is set into a Verson 300-HD1-120 press. 90 degree flange is formed, then acute angle, followed by formation of flange on previously cut notch after which hem is flattened.

The tenacious, protective zinc coat remains unimpaired, adhering to the base metal through deep drawing, bending, rolling, seaming, stamping and other operations.

This combination of properties is responsible for the recent development of a wider use of galvanized steel in the automotive industry. Critical corrosion problems in vital parts of the new unitized automotive members have been solved by the use of continuously zinc coated steel.

St. Joseph Lead Co. supplies zinc "electronically-matched" to the individual specifications of continuous line galvanizers.



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Dept. 31, WATERTOWN, N. Y.

For more information, circle No. 351

POTENTIAL USES FOR BUTON RESINS

Type ➡	100	200	300
Appliance Finishes		X	X
Industrial Finishes		X	X
Business Machine Finishes		X	X
Automotive Primers		X	X
Can Coatings	X	X	
Drum Enamels		X	X
Pipe Coatings		X	X
Tank Coatings		X	X
Gasket Coatings	X		
Wire Coatings		X	X
Furniture Finishes			X
Flat Steel Primers	X	X	X
Fiberboard Sealers			X
Glass Coatings			X

100 to introduce polar groups such as hydroxyls, carbonyls and carboxyl groups. The resulting polymers have a much more active chemical nature and slightly lower unsaturation than Buton 100. They are supplied in solutions.

Buton 200 and 300 resins can be used alone or can be blended with ureas, melamines, short and medium oil alkyds, vinyls, phenolics and nitrocellulose to obtain specific properties.

Properties

Enjay says Buton resin film properties are about the same as those of epoxy films but superior to alkyd-melamine films. Buton resin films are hard, tough and glossy, and have excellent resistance to water, chemicals, solvents and abrasion.

Outdoor weather tests show that Buton films have weather resistance properties comparable to those of epoxy films. Pigmented Buton films exposed outdoors for one year show chalking but retain good film integrity.

Curing can be done over wide range of conditions

The resins can be cured over a wide range of conditions varying from a few minutes at room temperature to a few seconds at flame-curing temperatures (600-1100 F). The flame-curing process uses an air-gas flame which is applied directly to a freshly coated surface. The combination of short exposure time and an oxygen deficient blanket provided by the flaming gases is said to result in a different cure than

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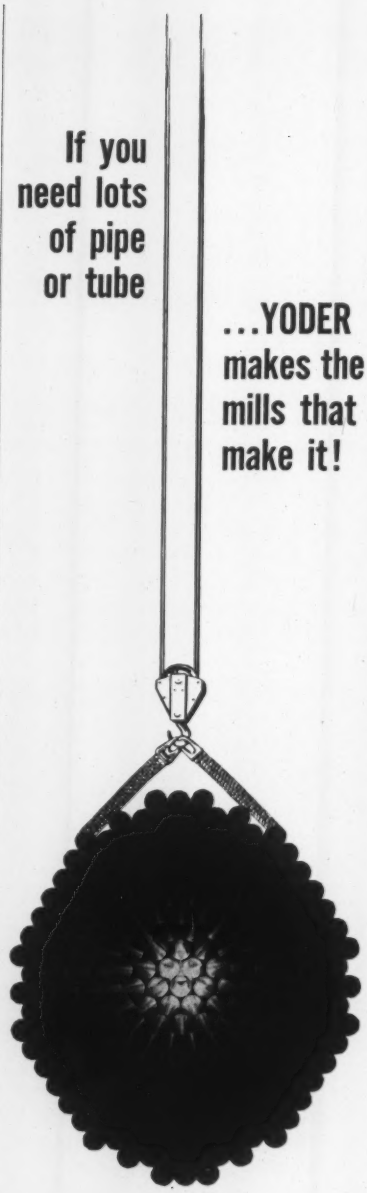

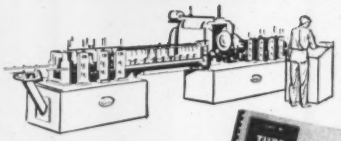

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5546 Walworth Avenue • Cleveland 2, Ohio

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PIPE AND TUBE MILLS
(ferrous or non-ferrous)

For more information, circle No. 394

PLASTICS
in Design
Engineering

New Teflon* FEP resin enables Garlock to supply mechanical and electrical parts of complexities never before achieved.

New developments in TEFLON FEP shapes and parts by Garlock. With the commercial availability of Teflon FEP, Garlock can now fabricate mechanical and electrical components never before possible with Teflon TFE. The reason is this—whereas TFE must be processed like powdered metals, the new FEP has the advantage of being melt-processed in conventional extrusion and injection molding equipment.

Think of what this means to you as a designer. You can now specify Teflon for the most delicate and complex shapes you may design. Teflon FEP opens whole new avenues of design possibilities . . . parts of the most intricate shapes . . . wall sections of minimum thinness of .020″-.030″ . . . pieces with the closest of tolerances. Garlock also furnishes Teflon FEP in rod stock for ready cutting and machining.

Another important point. Developed as a supplement to Teflon TFE, the new FEP resin exhibits the same fine physical properties of chemical inertness, top thermal stability, excellent dielectric strength, and outstanding anti-stick and frictional characteristics. FEP is rated at a continuous service ceiling of +400°F, will resist extreme cold down to −395°F.

At low temperature, FEP has more impact resistance than any other known plastic. It is virtually unaffected by weather and remains unchanged when subjected to ultra-violet light and ozone attack. Finally, water absorption of FEP is zero!

Turn to Garlock—and their years of experience in fabrication of plastics—for more information on stock shapes and intricate parts of new Teflon FEP. The Garlock representative serving you will be glad to give you complete details. Call him at the nearest of Garlock's 26 sales offices throughout the U.S. and Canada. Or, write for catalog, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Du Pont Trademark for TFE and FEP resins

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Have You Explored GRAPHITE As A Problem-Solving Material ?

Are you looking for an economical substance that combines machineability, chemical inertness, high thermal conductivity, high temperature stability, and resistance to thermal shock?

Are you looking for a material that has proved to be highly suitable for such diverse applications as vital nuclear reactor components, molds and dies for metals casting, sintering boats and trays, run-out tables and canisters, refractories, brazing fixtures, linings in chemical process equipment, thermocouple shields, and electric resistance furnace parts?

For an introduction to the excellence of GLC graphite—and to one of the world's outstanding graphite producers—write for a free copy of our illustrated brochure, "Graphite For Diversified Industrial Application".

PRODUCTS OF ELECTRODE GLC DIVISION YOU CAN TRUST

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N.Y. OFFICES IN PRINCIPAL CITIES

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SILICONE SEALS from Hadbar, Inc.

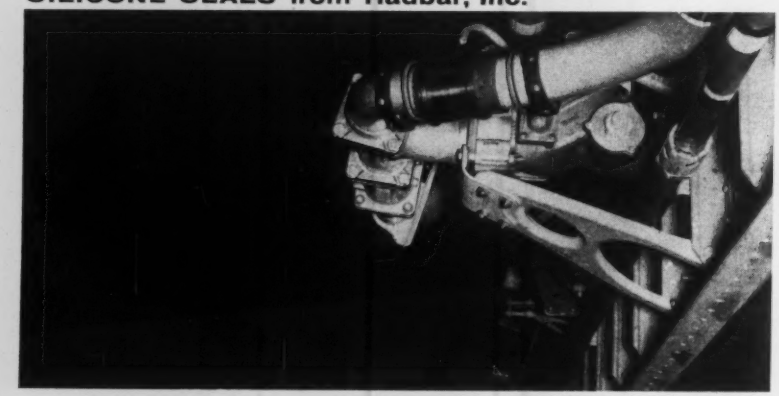

Photo courtesy of Douglas Aircraft Company

Fuel Resistant O-rings for Jets

Some 500 flexible fuel-line couplings on the DC-8 Jetliner are sealed by special Hadbar O-rings. For safety, the O-rings, like the two exposed above, must retain elastic properties and dimensional stability despite prolonged contact with jet fuel at temperatures from −80°F to +160°F.

Hadbar #1000-80, an elastomer based on Dow Corning's Silastic® LS fluorosilicone, was compounded and precision-molded by Hadbar technologists to meet exacting Douglas specifications. See Hadbar, Inc., for silicones, fluorosilicones, fluorocarbons and other advanced elastomers.

Write for complete information

HADBAR, INC.

Engineers and Manufacturers of Precision Molded and Extruded Elastomer Products

9530 GIDLEY STREET • TEMPLE CITY, CALIFORNIA • CU 3-4121

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What's new IN MATERIALS

conventional baking techniques: oxidation of the polymer is reduced and film formation relies on carbon-carbon crosslinking polymerization.

The flame-curing technique is being considered for curing coatings on light gage metal products, oil field pipes, and equipment too heavy or bulky for baking. KEY NO. 633

Rubber-to-Metal Seals Resist Heat, Solvents

Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif. is marketing two new rubber-to-metal products.

1. Gasket

One is a rubber-to-metal gasket called Still-Seal. It uses a fluorinated silicone rubber compound called TH-1057 that is said to have good resistance to solvents, jet fuels and oils. The gasket can be used over the temperature range −80 to 450 F. KEY NO. 634

2. Seal

The other new product is a rubber-to-metal seal called Permadize. The seal uses a butyl rubber compound called SR 617-75 that is said to have excellent resistance to Skydrol, a fireproof hydraulic fluid. Stillman says the new rubber-to-metal product will seal indefinitely to aircraft hydraulic systems. KEY NO. 635

Air-Curing Silicone Waterproofs Leather

An air-curing silicone water repellent for leather, paper and paperboard products has been developed recently by the Silicone Products Dept. of General Electric Co., Waterford, N. Y.

Designated SS-4024, the new material acts without catalysis or thermal cure, and can be applied by spraying, brushing and roll coating without any provision for heat after application.

The product is a solvent solution of silicone polymers and other film-forming components. It is effective as a coating for paper and paperboard products that may be exposed to dampness. As a water repellent for leather it can be used to treat

Out of this world . . .

MicroRold

MOON STEEL

Because stainless steel has helped to bring man's conquest of the heavens ever nearer, it has rightfully earned a new space-age name —MOON STEEL.

Since 1955, Washington Steel has been the exclusive supplier of light gage stainless steel sheet for the outer covering of the Atlas missile. The reason is simple: Washington Steel pioneered in the art of rolling stainless steel to uniform gages and has been able to meet the exacting specifications set up by space engineers for this momentous undertaking.

This is why MicroRold* stainless is truly out of this world!

WASHINGTON STEEL CORPORATION

Washington, Pa.

*REG. T.M.

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DALIC SELECTIVE PLATING for ELECTRONIC COMPONENTS

Plating circuit contacts without dismantling electronic components.

Quick Accurate Way to Plate:

- Semi-Conductors.
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- On site field repair of Electronic Computer Contacts.

Speeds Production in:

- Automatic plating of Transistor Tabs.
- Gold-plating on Aluminum.
- No-flux soldering on Aluminum and Stainless Steel.

Plate selected areas rapidly without disassembling components. Dalic Process accurately controls thickness of deposits. Produces quality plating.

No Immersion Tanks. Mobile Equipment.

Plating equipment can be moved to the job. Quick, easy to use with Dalic hand-stylus, power pack, and the Dalic plating solutions. Mechanized production can be devised.

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What's new IN MATERIALS

sports equipment, luggage, gaskets, diaphragms and belts.

The water repellent sells for $1.77 per lb in drum lots. KEY NO. 636

Glass-Bonded Mica Has Smooth Finish

A special grade of glass-bonded mica can have 10-18 μ in. finishes for use as potentiometer coil forms. The smooth finish permits tiny, 0.003-in. thick wires to be wound smoothly and evenly, so that a brush riding across the coil form will not bump or chatter.

The material, called Mykroy 1116, is available from Electronic Mechanics, Inc., Clifton, N. J. It withstands operating temperatures up to 1000 F, and has excellent electrical characteristics.

The new material is supplied in the form of centerless ground solid rods, in short tubular forms with minimum wall thicknesses of 0.070 in., and in custom-machined parts. KEY NO. 637

Other News . . .

Metals

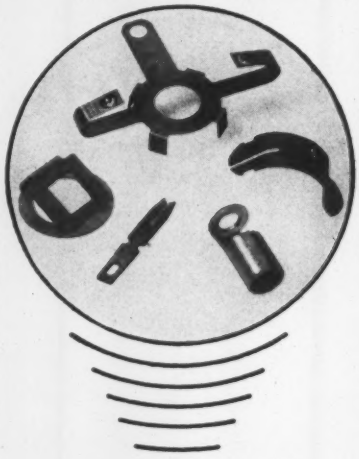
▸ Superior Tube Co., Box 191, Norristown, Pa. has introduced small-diameter straight and reverse tapered tubing, furnished with either constant or tapered wall. Size range of the new tubing is 0.080 to 1.50 in. o.d., with wall thicknesses ranging from 0.012 to 0.0625 in. The tubing can be supplied in carbon and alloy steels, stainless steels, nickel and nickel alloys, beryllium copper, titanium and Zircaloys. KEY NO. 638

▸ An air or oil hardening, high chromium die steel is said to have good machinability and excellent resistance to galling. The steel, called No. 1 FM, is available in the form of hollow bars from Darwin & Milner, Inc., 2222 Lakeside Ave., Cleveland 14, Ohio. Sizes range from 2¼ to 16¼ in. o.d. KEY NO. 639

Plastics and rubber

▸ A new series of general purpose polyethylene film grade resins has been announced by Dow Chemical Co.,

MORE BOUNCE TO THE MILLIGRAM



Somers THIN STRIP

PHOSPHOR BRONZE

From .000125" thin to .010", Somers Thinstrip phosphor bronze is produced by a unique high-speed annealing process which provides a uniform *fine grain* structure. Thus, spring temper metal is produced with elongation up to five times that of coarse grain methods, making possible the forming of much more intricate parts for many instrument and electro-mechanical applications. And Somers' close control of grain size guarantees prolonged fatigue resistance unattainable through ordinary methods.

Whatever your Thinstrip problems, in copper, copper alloys and stainless steel from .010" down and nickel and nickel alloys from .020" down, write for the Somers confidential data blank. No obligation, of course.

FOR EXACTING STANDARDS ONLY

Somers THIN STRIP

Somers Brass Company, Inc.

108 BALDWIN AVE., WATERBURY, CONN.

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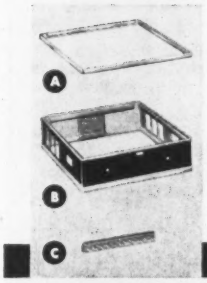
HELPS PRODUCE ANOTHER NEW PRODUCT



This new Webcor tape recorder weighs 19 lbs., has a case with three vital parts of extruded aluminum by General Extrusions Inc. G.E.I. engineers easily met the manufacturer's design specifications, then the parts were formed, drilled, punched, mitered, anodized and spray painted in G.E.I.'s modern plant in time to meet exacting delivery schedules. Why not let G.E.I. help get your new product off the drawing board and into production?

GENERAL EXTRUSIONS INC.

P. O. Box "J," 4040 Lake Park Road
Youngstown 7, Ohio

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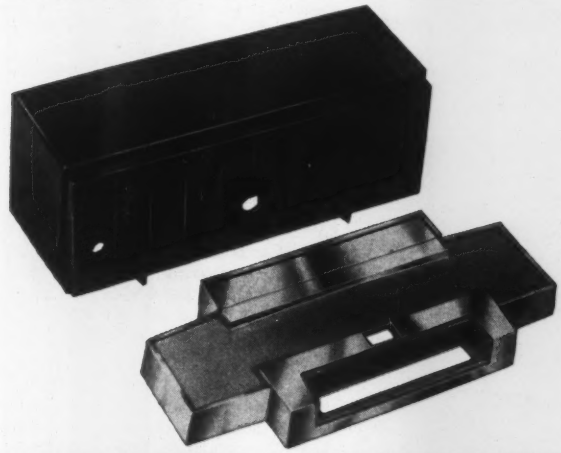

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RITCO FORGINGS

dependable shock-strength stands severest service

Hammer-compacted toughness makes Ritco Forgings your logical choice when parts must be *dependably* strong. Ritco's long experience in controlling grain flow assures the metallurgical structure having greatest fatigue strength — provides extra strength and impact resistance at points of greatest shock and stress. And Ritco's smooth "Bright Finish" and close-tolerance accuracy save real money in machining and assembly time. We will be pleased to quote to your specifications.

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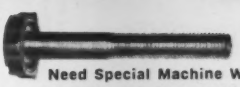

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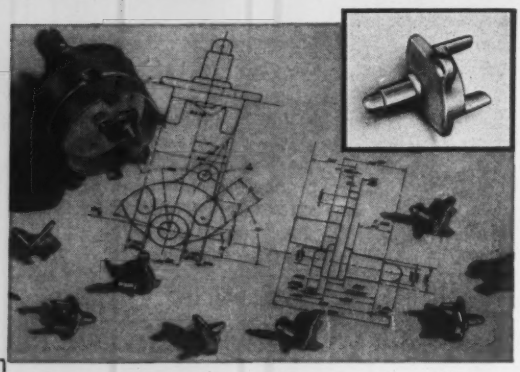
"IMPOSSIBLE" PART

die cast for MALLORY by GRC

helped create higher rated, longer lasting switch



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"Impossible", yes, by any other method. But—GRC's unique single cavity die casting techniques made possible a detailed and complex actuating mechanism with exceptional requirements of uniformity and accuracy. Inspired Mallory engineers to design a new and better switch around this GRC die cast mechanism! Just another instance in which GRC's exclusive patented methods have solved a parts problem and opened the door to a new product . . . at substantial savings.

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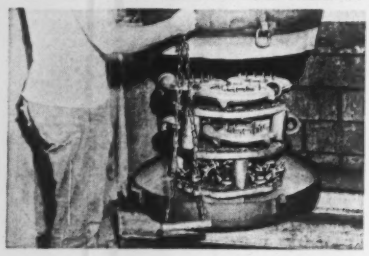
Stainless Brazing Program Reduces B-58 Aircraft cost

Complex Turbine Assembly Brazed in One Operation

Accurately controlled assembly by brazing is the method used to speed production of compressor turbines for the B-58 aircraft. Turbines are of stainless steel, are used in aircraft's air conditioning system. More than 60 separate pieces forming turbine are simultaneously brazed with dimensional tolerance held within .002 in. Brazing is done with Nicrobraz (Standard) filler metal under pure dry hydrogen atmosphere at 2150° F. Cooling rate is controlled. Work is done on mass production basis by Stainless Processing Division.



Nicrobraz® Processing Benefits:

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- More than 60 parts joined in one brazing operation
- Distortion held to within ±0.002"
- No finish machining was needed
- Brazed assembly was fully annealed
- No clean-up, assembly was bright and clean

Our stainless brazing facilities can help you solve production problems. Call or write for full information.

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Representatives in all key industrial areas

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What's new IN MATERIALS

Midland, Mich. The resins are said to combine excellent surface gloss and high clarity with high impact properties. They are called 531E.

KEY NO. 640

▸ Vulkollan, the original urethane rubber developed in Germany, is now available in this country in the form of sheets, strips, rods and tubes from Moldex Co., P. O. Box 51, Yonkers, N. Y. The parts are supplied in Durometer hardnesses ranging from A70 to A95.

KEY NO. 641

Other nonmetallics

▸ Newcomer Products, Inc., Latrobe, Pa. has introduced five new grades of cemented carbides. The materials, called NewBide, have Rockwell hardnesses ranging from A91 to A93 and transverse rupture strengths ranging from 225,000 psi to 325,000 psi. The carbides are recommended for machining and cutting ferrous and nonferrous metals.

KEY NO. 642

▸ A new type of glass has been developed by Corning Glass Works, Corning, N. Y. for use in calibrating spectrophotometers. The developer says accuracy of the instrument can be determined in a few minutes by using filters made of the glass. The glass is called Code No. 3130 and is available in the form of flat plates.

KEY NO. 643

Finishes

▸ Pittsburgh Plate Glass Co., 632 Ft. Duquesne Blvd., Pittsburgh 22 has introduced a one-coat acrylic baking enamel for use on aluminum siding. The coating, designated Duracron, is said to have excellent resistance to corrosive salt air and industrial fumes. It is supplied in a complete range of colors.

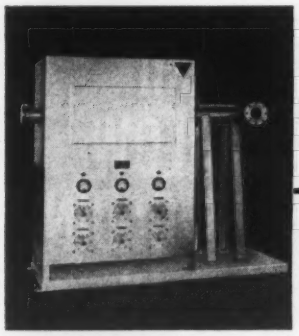
KEY NO. 644

▸ A bright copper cyanide plating process has been developed by Harshaw Chemical Co., 1945 E. 97th St., Cleveland 6, Ohio. The developer says the process, called Cynorex, is easy to operate since it uses only one addition agent; other cyanide plating processes usually require two or more addition agents.

KEY NO. 645

▸ A 100% solids, single-component epoxy coating has been designed for use at temperatures up to 310 F. The coating is called HumiSeal Type 1F56. It is available from Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway West, Woodside 77, N. Y.

KEY NO. 646



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for precision control of temperatures up to 2800° F

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Gasketed metallic seals at both ends of the tube insure gas-tight closure. Loading end of tube provides a preheat zone. Unloading end has a water-cooled jacket and provision for connecting a vacuum system for drawing a vacuum in the tube for gas-free atmosphere.
Unit's overall length is 60". Case is reinforced, welded steel with super-duty, graded insulation. Available in other sizes or modifications. Write.

Standard and Special Units
450 to 5000 F.

Also Available
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PERENY EQUIPMENT COLUMBUS O

PERENY EQUIPMENT CO., INC.
Dept. A, 893 Chambers Rd., Columbus 12, Ohio

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REVCO

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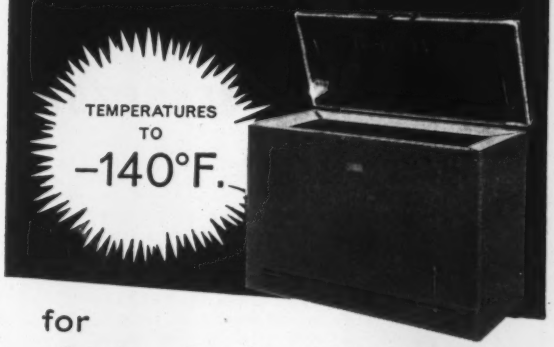

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Industrial Products Div.,
REVCO INC.
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

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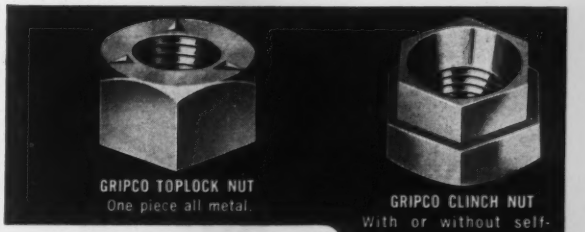
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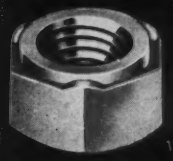

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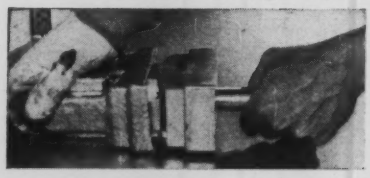

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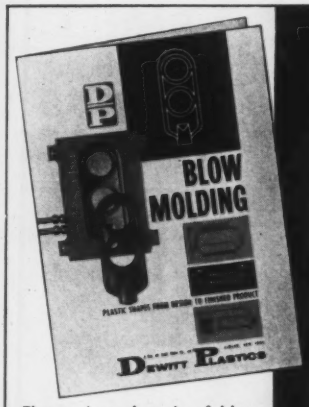

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For free technical literature on all kinds of engineering materials, forms and finishes, see pp 37-41.

PAGE NOS.

Adhesives 101-102

Bars, cold finished..... 70
Bearing materials..... 112
Beryllium and its alloys..... 68
Bimetals, thermostatic..... 140
Brazing alloys.....51, 160
Brazing, high temperature.. 160

Carbides, cemented..... 122
Carbon, graphite.....126, 156
Casting alloys..... 2-3
Castings 106
  Continuous 20
  Die 27, 64-65, 134, 152, 160
  Shell mold..... 138
Ceramics 45, 50, 144
Ceramoplastics 28
Cleaners, metal 24
Coatings
  Chemical conversion.....24, 57, 131, 149
  Diffusion 116
  Dip 135
  High temperature..... 115
  Organic 109, 120, 149
  Sodium nitrite..... 125
Cold treating cabinets..... 161
Copper and its alloys.....inside front cover, 20, 110, 158

Diaphragms 25

Extrusions
  Metallic 159
  Nonmetallic 156

Fabrics, coated 25
Fasteners, mechanical ..34, 66-67, 126, 161
Felts .....162, inside back cover
Finishing machines..... 29
Forgings .....142, 147, 159, outside back cover
Furnaces, high temperature. 161

Insulation 32, 53-54, 101-102

Laminates, plastics...62, 108, 115
Lead and its alloys..... 56
Low melting alloys..... 162

Magnetic alloys..... 44
Mica 28
Mica, glass-bonded 28

Nickel and its alloys.....4, 46

PAGE NOS.

Papers 130, 154
Plastics
  ABS 6, 104
  Cellulose acetate butyrate. 33
  Fluorocarbons 53-54, 58-59, 121, 155
  Phenolics 128, 135
  Polyamides (nylon) 112
  Polycarbonate 47
  Polyesters 135
  Polyethylenes 30-31, 42-43
  Polystyrene 48-49
  Polyvinylidene fluoride.... 133
  Reinforced ...105, 114, 115, 141
  Vinyls 109
Plastics moldings.....30-31, 159
Plating processes, solutions.. 158
Precision parts, metal..... 150
Precoated & preplated metals 18, 60-61, 153
Pressure gages..... 124

Rayon fibers..... 63
Refractory materials..... 123
Rings, nonmetallic "o"..... 156
Rubber
  Moldings 156
  Silicone 113
  Urethane 52

Seal rings..... 122
Silicones 32, 101-102
Springs 118
Stampings, punchings..... 29
Steel 117
  Carbon 8
  Heat & corrosion resistant 8, 66-67, 136-137, 157
  Leaded 8
  Low alloy.....8, 46, outside back cover
  Specialty 107
  Tool and die..... 111
Strip, precision rolled..... 158
Superalloys 129, 143

Tapes 53-54
Testing equipment.....22, 148
Tubing & pipe, metallic....26, 66-67, 145, 151, 154

Vacuum melted alloys..... 119

Wire 4, 139
Wire cloth..... 146
Wire forms..... 136
Wood 55

X-ray film..... 127

Zinc and its alloys..... 2-3

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and their agencies

Use this index for the latest information on how and where to use **materials, forms and finishes** . . . because more companies advertise these products in the thirteen issues of MATERIALS IN DESIGN ENGINEERING than in any other magazine.

Advance Tool and Die Casting Co. 27
Ken Seitz & Associates, Inc.

*Allied Chemical Corp., Solvay Process Div. 125
Kastor, Hilton, Chesley, Clifford & Atherton, Inc.

*Allied Research Products, Inc. 149
Emery Advertising Corp.

*American Felt Co. .....3rd Cover
Kelly, Nason, Inc.

American Lava Corp. 45
Designers, Inc.

American Nickeloid Co. 18
Keneth B. Butler & Associates

*American Smelting and Refining Co., Continuous Cast Dept. 20
Ward William & Co.

*American Viscose Corp. 63
Arndt, Preston, Chapin, Lamb & Keen, Inc.

AmForge Div., American Brake Shoe Co. .. 142
Fuller & Smith & Ross Inc.

Ampco Metal, Inc. 110
Hoffman, York, Paulson & Gerlach, Inc.

Anaconda American Brass Co. .....2nd Cover
Kenyon & Eckhardt, Inc.

*Art Wire & Stamping Co. 136
Williams and London Advertising

Babcock & Wilcox Co., Tubular Products Div. 26
O. S. Tyson and Co., Inc.

Bean, Morris, and Co. 106
Odiorne Industrial Advertising, Inc.

*Beryllium Corp. 68
Arndt, Preston, Chapin, Lamb & Keen, Inc.

Bethlehem Steel Co. 111, 139, 147
Hazard Advertising Co., Inc.

Bishop, J., & Co. Platinum Works..... 145
Richardson, Thomas & Bushman, Inc.

Carlson, G. O., Inc. 136, 137
Foltz-Wessinger, Inc.

Carpenter Steel Co. 143
Beaumont, Heller & Sperling, Inc.

Ceilcote Co., Inc. 114
Penn and Hamaker, Inc.

*Cerro Sales Corp. 162
Thoma & Gill

Chace, W. M., Co. 140
Clark & Bobertz, Inc.

Chemo-Products, Inc. 53, 54
Funt-Rand, Inc.

Chromalloy Corp. 116
Faulkner Advertising, Inc.

*Colonial Rubber Co. 113
Ralph Gross Advertising, Inc.

Conforming Matrix Corp. 29
Wendt Advertising Agency

Continental-Diamond Fibre Corp., Sub. of Budd Co. 62
Aitkin-Kynett Co., Inc.

*Continental Felt Co. 162
Daniel H. Price, Inc.

Copperweld Steel Co. 8
Bayless-Kerr Co.

Dewitt Plastics Div., Shoe Form Co., Inc. .. 162
Spitz Advertising Agency

*Dixon Corp. 121
Horton, Church & Goff, Inc.

Doehler-Jarvis Div., National Lead Co. ..64, 65
McCann-Marschalk Co.

Dow Corning Corp. 101, 102
Church and Guisewite Advertising, Inc.

*du Pont de Nemours, E. I., & Co., Inc. Elastomer Chemicals Dept. 52
N. W. Ayer & Son, Inc.

*du Pont de Nemours, E. I., & Co., Inc. Film Dept. 58, 59
Batten, Barton, Durstine & Osborn, Inc.

*Duraloy Co. 138
Sanger-Funnell, Inc.

*Durez Plastics Div., Hooker Chemical Corp. 135
Rumrill Co., Inc.

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Eastman Chemical Products, Inc., Plastics Div. 33
Fred Wittner Co.

Eastman Kodak Co., X-ray Div. 127
J. Walter Thompson Co.

*Fiberite Corp. 105
Harold C. Walker Advertising

Foster Grant Co., Inc. 48, 49
Donahue & Co., Inc.

Frenchtown Porcelain Co. 50
Michener Co.

Gamble Brothers, Inc. 55
Doe-Anderson Advertising Agency, Inc.

Garlock Inc. 155
Hutchins Advertising Co., Inc.

General Electric Co., Chemical & Metallurgical Div. 47
G. M. Basford Co.

General Electric Co., Silicone Products Dept. 32
Ross Roy-Brooke, Smith, French & Dorrance, Inc.

*General Extrusions, Inc. 159
R. J. McCallister Co.

Goodrich, B. F., Chemical Co. 6
Griswold-Eshleman Co.

Grace, W. R., & Co., Polymer Chemicals Div. 42, 43
Charles W. Hoyt Co., Inc.

*Graphite Specialties Corp. 126
Scheel Advertising Agency, Inc.

Great Lakes Carbon Corp., Electrode Div... 156
Davis, Parsons & Strohmeier, Inc.

Gries Reproducer Corp. 160
Harold Marshall Advertising Co., Inc.

*Grip Nut Co. 161
Ross Llewellyn, Inc.

Hadbar, Inc. 156
Associated Business Consultants

*Handy & Harman 51
Hazard Advertising Co., Inc.

Haynes Stellite Co., Div. of Union Carbide Corp. 129
J. M. Mathes, Inc.

*Instrument Specialties Co., Inc. 118
George Homer Martin Associates

International Nickel Co., Inc. 4, 46
McCann-Marschalk Co.

*Kennametal, Inc. 122
Ketchum, MacLeod & Grove, Inc.

Kinney Vacuum Div., New York Air Brake Co. 124
Humbert & Jones, Inc.

*Knowlton Brothers, Inc. 154
Barlow Advertising Agency, Inc.

*Latrobe Steel Co. 107
McHenry-Derek Advertising

Lead Industries Association 56
O. S. Tyson and Co., Inc.

Lukens Steel Co. 117
J. M. Mathes, Inc.

*Marbon Chemical Div., Borg-Warner Corp. 104
Holtzman-Kain Advertising

Materials in Design Engineering..... 132

Materials Selector 162

McDanel Refractory Porcelain Co. 144
Meek and Thomas, Inc.

*Metal & Thermit Corp. 120
Marsteller, Rickard, Gebhardt and Reed, Inc.

Midwest Steel Corp., Div. of National Steel Corp. 60, 61
Campbell-Ewald Co.

Mosinee Paper Mills Co. 130
Buchen Advertising, Inc.

*Mycalex Corporation of America 28
Kelley, Nason, Inc.

*New Jersey Zinc Co. 2, 3

*Newark Wire Cloth Co. 146
Sanger-Funnell, Inc.

Northwest Chemical Co. 131
F. B. Hubert, Advertising Counselors

*Norton Co., Refractories Div. 123
Chirurg & Cairns, Inc.

*Oakite Products, Inc. 24
Marsteller, Rickard, Gebhardt and Reed, Inc.

Parker Rust Proof Co. 57
Fred M. Randall Co.

Pennsalt Chemicals Corp., Research Products Development Dept. 133
Aitkin-Kynett Co., Inc.

Pereny Equipment Co., Inc. 161
Wheeler, Kight & Gainey, Inc.

*Permali, Inc. 108
McHenry-Derek Advertising

*Plastics Engineering Co. 128
Kuttner & Kuttner, Inc.

*Polymer Corp., Molded Resins Div. 112
Beaumont, Heller & Sperling, Inc.

Raybestos-Manhattan, Inc., Reinforced Plastics Dept. 141
Gray & Rogers

*Reeves Brothers, Inc., Vulcan Rubber Products Div. 25
Ketchum, MacLeod & Grove, Inc.

*Reichert Float & Mfg. Co. 29
Wendt Advertising Agency

*Republic Steel Corp. 66, 67
Meldrum & Fewsmith, Inc.

Revco, Inc. 161
Howard Swink Advertising Agency, Inc.

*Rhode Island Tool Co. 159
Horton, Church & Goff, Inc.

Riehle Testing Machines Div., American Machine and Metals, Inc. 22
L. W. Ramsey Advertising Agency

*Russell, Burdsall & Ward Bolt and Nut Co. 126
Marsteller, Rickard, Gebhardt and Reed, Inc.

Ryerson, Joseph T., & Son, Inc. 70
Buchen Advertising, Inc.

St. Joseph Lead Co. 153
Emil Mark & Co., Inc.

Sifco Metachemical, Inc. 158
Crier Advertising Service

*Simmons Fastener Corp. 34
Fred Wittner Co.

Sinko Manufacturing and Tool Co. 159
Allen J. Siegel Advertising

*Somers Brass Co., Inc. 158
Charles Palm & Co., Inc.

*Superior Tube Co. 151
Gray & Rogers

*Swedlow Inc. 115
Willard G. Gregory & Co.

Timken Roller Bearing Co., Steel & Tube Div. ..... Back Cover
Batten, Barton, Durstine & Osborn, Inc.

Titan Metal Manufacturing Co., Div. of Cerro Corp. 134
Sykes Advertising, Inc.

Torrington Co., Specialties Div. 150
Hazard Advertising Co., Inc.

*Twin City Die Castings Co. 152
Wm. L. Baxter Advertising

*Union Carbide Plastics Co., Div. of Union Carbide Corp. 30, 31
J. M. Mathes, Inc.

United States Stoneware Co., Plastics and Synthetics Div. 109
Ralph Gross Advertising, Inc.

Vanadium-Alloys Steel Co. 119
Downing Industrial Advertising, Inc.

*Wall Colmonoy Corp., Stainless Processing Div. 160
Hemsing Advertising

Washington Steel Corp. 157
Cabbot & Coffman, Inc.

Weirton Steel Co., Div. of National Steel Corp. 60, 61
Campbell-Ewald Co.

Westinghouse Electric Corp., Materials Mfg. Dept. 44
Fuller & Smith & Ross Inc.

Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc. 148
Reincke, Meyer & Finn, Inc.

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The reason is simple: technical men, for the most part, cannot read foreign languages, and even if they could European publications are not readily available to them. The only present sources of foreign technical information are brief abstracts or translations which usually do not appear until many months after original publication of an article.

Cover-to-cover translations

It would seem to be in our best interests to devise a more effective way of keeping engineers informed about foreign developments. Therefore, we would like to suggest that serious consideration be given to setting up some arrangement for cover-to-cover translation of important German, French, Italian, Scandinavian and Spanish technical publications—thus going a long step beyond current efforts confined mainly to Russian journals.

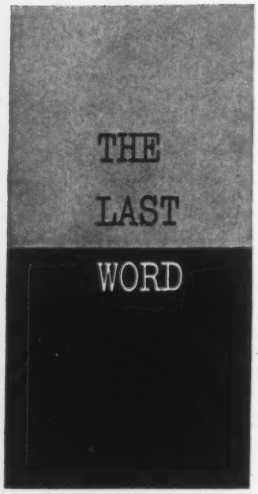
In essence, such an arrangement would probably include the following elements:

1. The leading foreign magazines covering materials would be selected by authorities.
2. With permission of foreign publishers, all the editorial matter, but no advertisements, would be translated into English.
3. The translated publications in given areas (such as metals, nonmetals, corrosion, testing) could be bound together in separate volumes if feasible.
4. To keep costs to a minimum, low cost printing methods and paper would be used.
5. The translated publications would be offered at the lowest possible cost.

Government help necessary

Who should tackle such an undertaking? Because of the scope and cost, it is doubtful that a society or a private organization could handle it. The task would require government action and support. Probably the Office of Technical Services, Dept. of Commerce, which is now disseminating foreign technical information on a small scale, would be best qualified.

Yes, the cost of this proposal would be high. But, through wider distribution of foreign literature much needless duplication of effort would be eliminated and the cost of the effort would be returned many times over.—D. PECKNER



. . . More U.S. Support of International Standards

In still another international area—that of standards—we as a nation are sadly deficient in our efforts. At present the United States has representation on only 50 of the 100 committees in the International Standards Assn. In a recent article in *ASTM Bulletin*, Arnold Scott, National Bureau of Standards, who has represented the United States at many international meetings said: "I'm deeply concerned with the lack of interest in this country in international standards. We are too smug in our feeling that our technology and industry lead the world—that our way is best, that we do not need international standards."

Here, again, as in our failure to keep informed of foreign technical advances, we will suffer if our disinterest continues. Scott points out that "If we are to share in international markets—especially the markets opening up in underdeveloped countries—we must become more standards-minded. . . . (Also) we should take a more active part . . . to make sure that our point of view is well represented."

In addition to helping our trade relations with other countries, active participation in international standards work provides a means for exchanging valuable ideas and engineering information.

Last year we were able to raise nearly one million dollars to send our olympic team to Rome. Only a fraction of this amount would be needed to multiply many times our representation on international standards committee. We think it would be worth it.—H. R. CLAUSER

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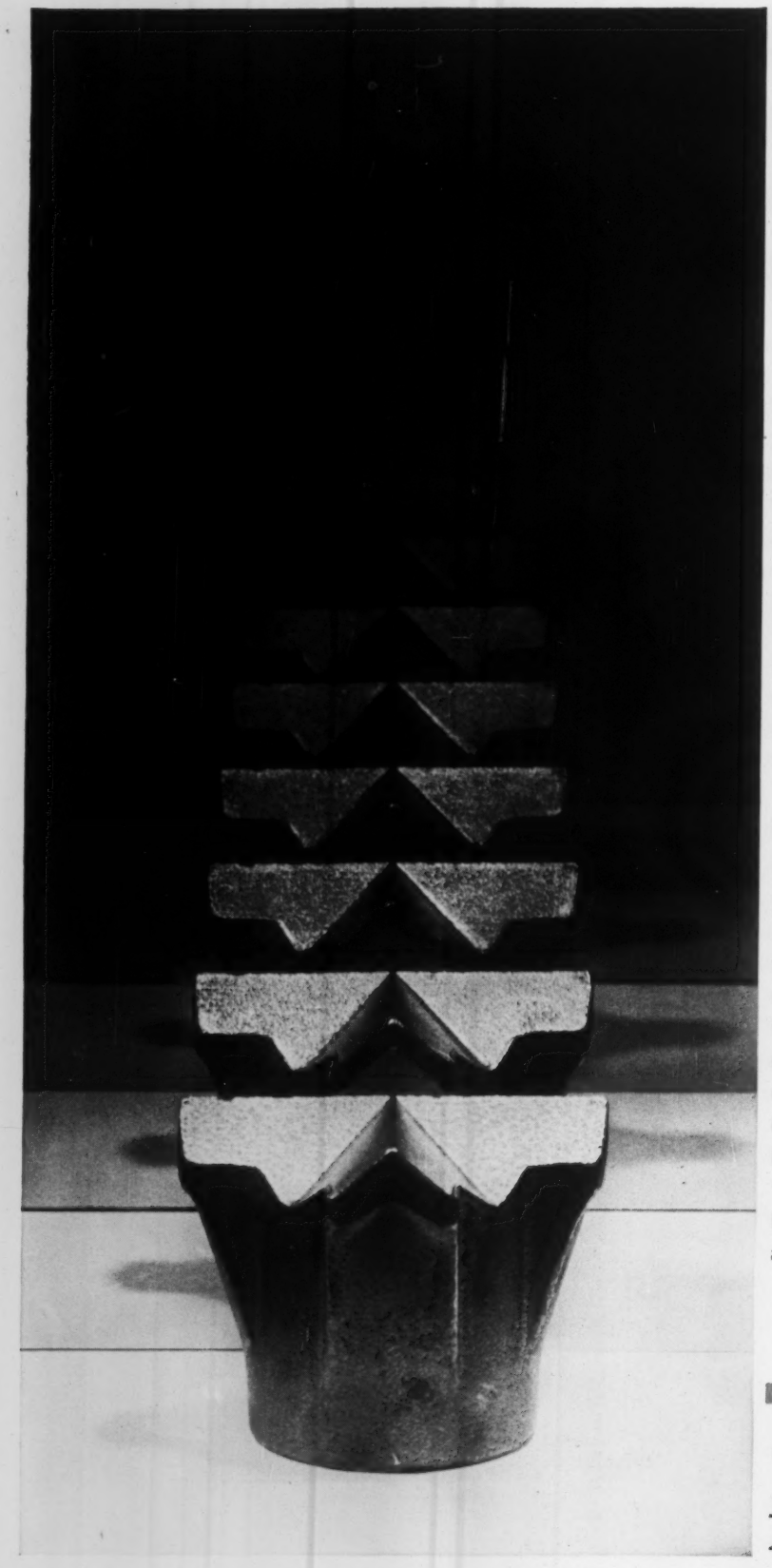

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